TM 11-2007

WAR DEPARTMENT TECHNICAL MANUAL

TELEPHONE REPEATER TP-14

TELEMARINE COMMUNICATIONS CO.
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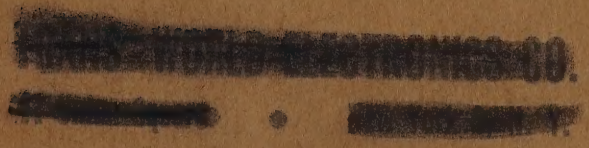

WAR DEPARTMENT *FEBRUARY 1945*

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TELEPHONE REPEATER TP-14

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TRANS-WORLD ELECTRONICS CO.
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WAR DEPARTMENT,
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TM 11-2007, Telephone Repeater TP-14, is published for the information and guidance of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

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For explanation of symbols, see FM 21-6.

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DESTRUCTION NOTICE

WHY — To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN — When ordered by your commander.

HOW — 1. Smash — Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.

2. Cut — Use axes, handaxes, machetes.

3. Burn — Use gasoline, kerosene, oil, flame throwers. incendiary grenades.

4. Explosives — Use firearms, grenades, TNT.

5. Disposal — Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT — 1. Smash — Transformers, filter coils, repeating coils, vacuum tubes, tube sockets, resistors, capacitors, all switches, rectifier, receiver, fuses, and fuse mountings.

2. Cut — All chassis wiring and power cord.

3. Burn — All remaining equipment, smashed parts, technical manuals, and circuit labels.

4. Bury or scatter — All the above pieces after destroying their usefulness.

DESTROY EVERYTHING

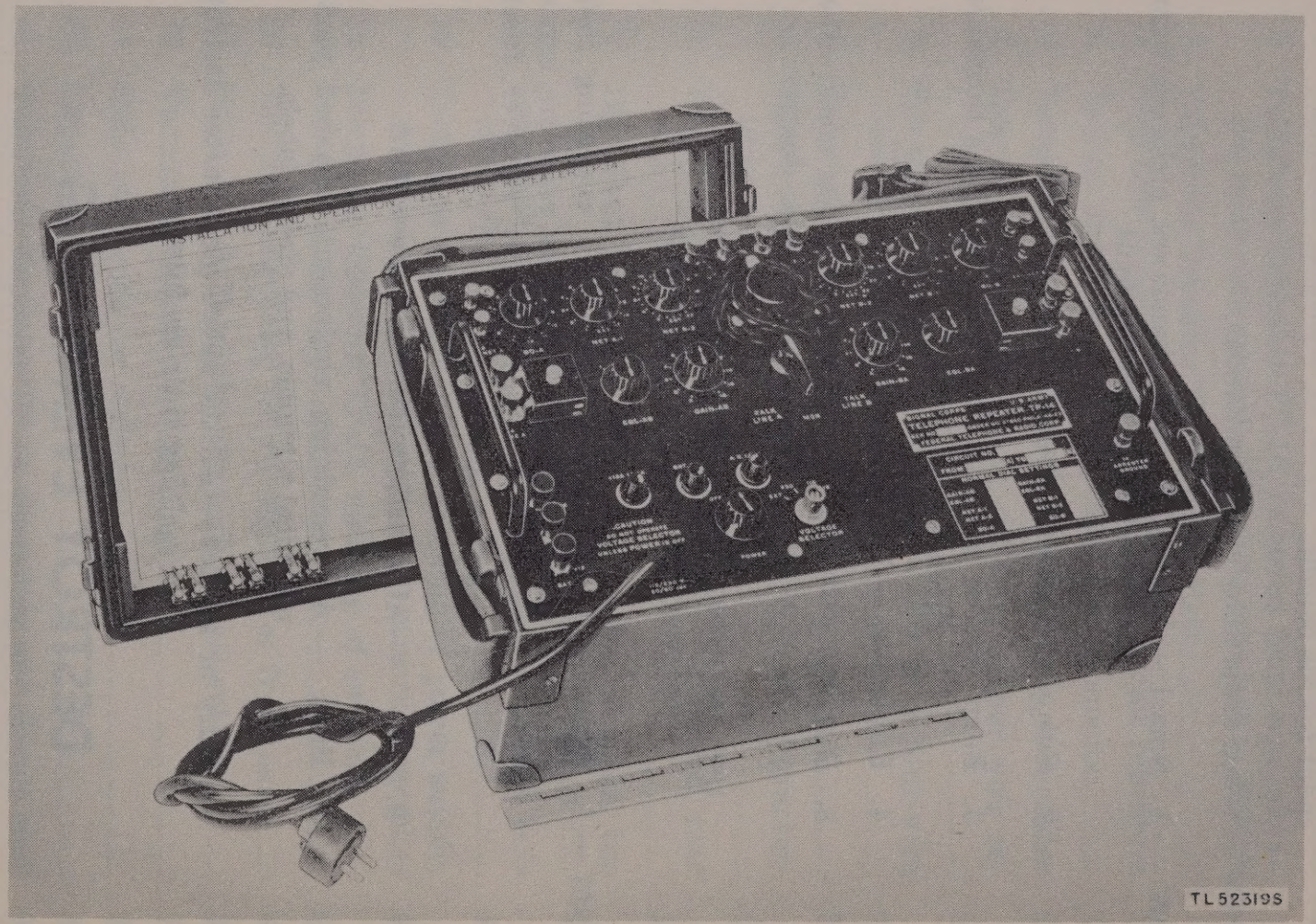

Figure 1. Telephone Repeater TP-14.

SECTION I

DESCRIPTION

1. GENERAL.

a. Telephone Repeater TP-14 (fig. 1) is a portable unit for extending the telephonic communication range of two-wire military line facilities. It may be used at terminal or intermediate points, at the junction of different types of line facilities, and at points where entrance cables are used.

b. Telephone Repeaters TP-14 may be used in tandem to extend communication circuits for distances in excess of those which may be realized by the use of Telephone Repeater EE-89-A. This is particularly true in the case of lines made up of mixed facilities, such as combinations of open wire and field cable.

c. The repeater spacings and the maximum length of line on which the repeaters can be used are limited by the balance which can be obtained between the lines and the balancing networks. More detailed information with regard to the distance which can be spanned with this equipment is given in paragraph 11.

d. Telephone Repeater TP-14 can be used as a 21-type repeater, or as a special form of repeater for interconnecting two-wire and four-wire facilities, or as a special form of four-wire repeater.

2. FEATURES.

a. Telephone Repeater TP-14 is a completely self-contained 22-type repeater and includes the necessary amplifiers, filters, equalizers, line balancing networks, and power supply equipment.

b. Balancing networks are provided for a wide variety of line facilities as shown below.

(*1*) Open wire, 80 to 165 mil copper.
(*2*) Open wire, 80 to 104 mil copper-steel.
(*3*) Open wire, 109 mil steel.
(*4*) Wire W-110-B, loaded and nonloaded.
(*5*) Wire W-143, loaded and nonloaded.
(*6*) Cable Assemblies CC-358, loaded.
(*7*) Cable pairs, 16 and 19 gauge, loaded.

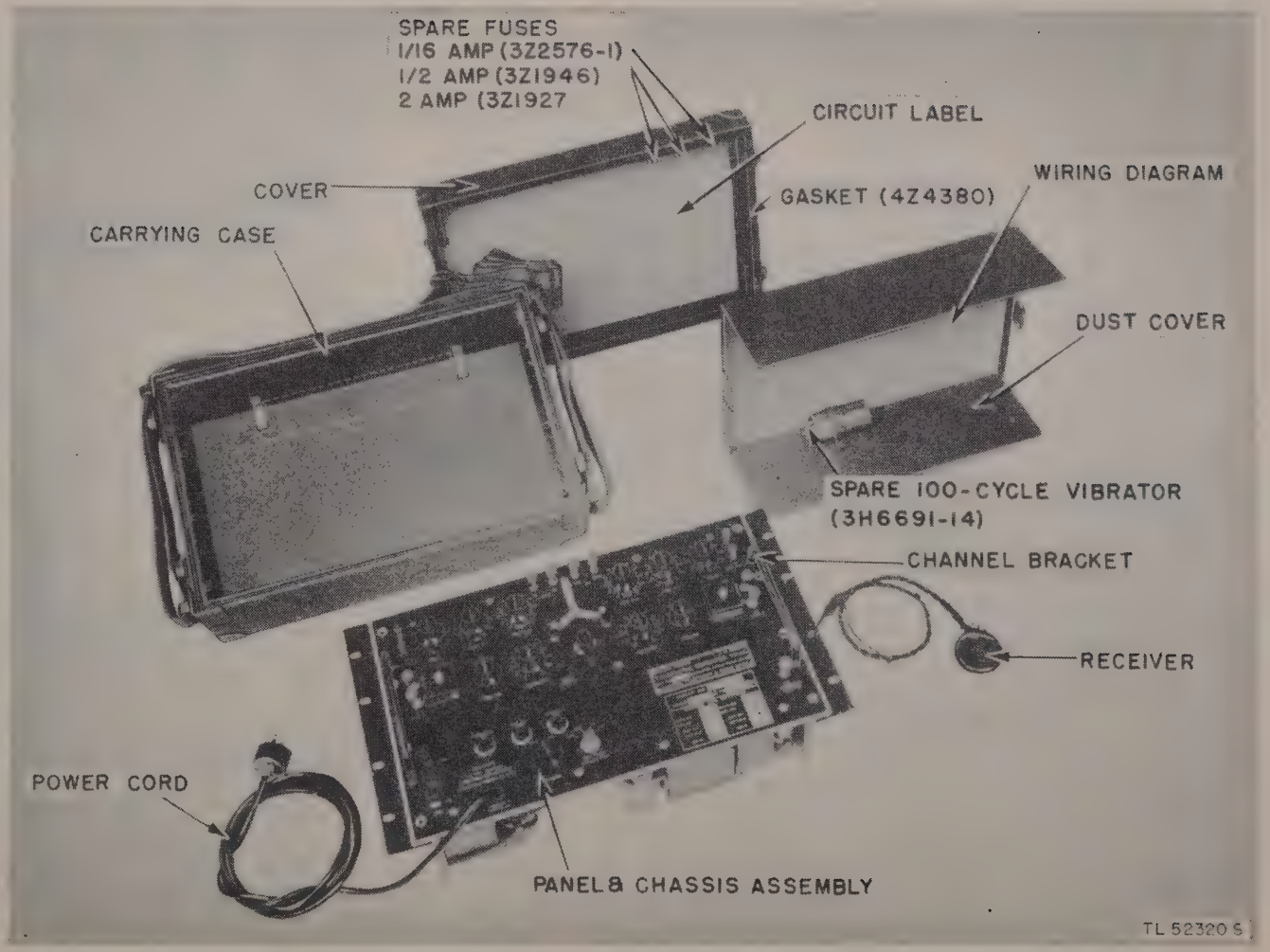

Figure 2. Tetephone Repeater TP-14, removed from case, showing relay rack mounting brackets attached to chassis.

c. In addition to the facilities above, some other types of lines may be balanced by appropriate adjustment of the networks or by means of external networks connected to binding posts on the unit.

d. Each network includes a variable building-out capacitor for balancing moderate lengths of nonloaded entrance cables at the end of the repeater section. Such cable must be of a kind which is stable with respect to weather conditions.

e. The equipment includes arrangements for passing 20-cycle signaling currents around the repeater which permit carrying through, tapping, or dropping the simplex or phantom circuit at a repeater point.

3. EQUIPMENT ARRANGEMENT.

a. Telephone Repeater TP-14 is housed as a complete unit in a plywood case, approximately 17½ inches long, 11 inches wide, and 8 inches high. The weight is approximately 46 pounds. The case will exclude moisture under ordinary weather conditions, but will not stand complete immersion in water. The unit is supplied with an adjustable carrying strap.

b. The equipment comprising the telephone repeater is mounted on a metal chassis and panel assembly fastened to angle brackets in the case. The entire chassis and panel assembly may be removed from the case (fig. 2) and mounted on a standard 19-inch relay rack using the end brackets furnished for this purpose. A removable dust cover protects the equipment on the rear of the panel.

c. The amplifier unit and balancing network units, with their associated building-out capacitors, are each mounted on a subchassis secured beneath the panel, and are removable as units. The power supply equipment is mounted directly on the main chassis.

d. Simplex taps are available for d-c telegraph operation.

e. Twenty-cycle signaling equipment, consisting of a transformer, a retard coil, and two capacitors provide means for bypassing 20-cycle ringing signals around the repeater.

f. Spare parts consisting of two vacuum tubes, two sets of fuses, and one vibrator are furnished with each repeater.

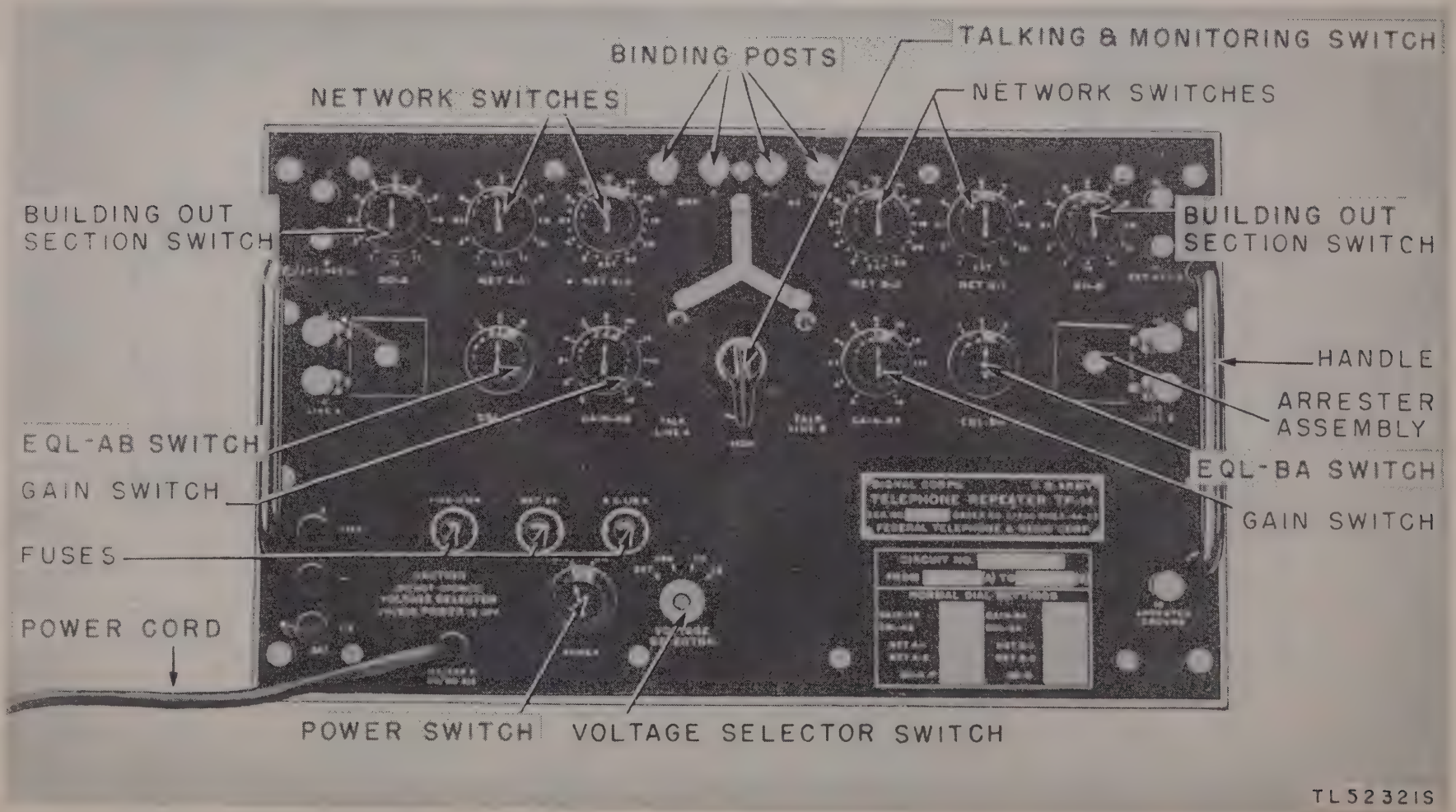

Figure 3. Telephone Repeater TP-14, panel view.

4. POWER SUPPLY.

The power supply equipment, contained within the unit, operates from alternating current, storage battery, or dry cells. The power requirement or current drain for each type of supply is as follows:

Source	*Approximate power (watts)*	*Approximate drain (milliamperes)*
110/130-volt, 50/60-cycle	11	
220/250-volt, 50/60-cycle	11	
12-volt storage battery		800
135-volt dc†		20
12-volt dc (dry cells)†		150

5. EXTERNAL CONNECTIONS.

a. Binding posts are provided for making external connections. Figure 3 shows the arrangement of binding posts on the face of the panel.

(*1*) The LINE A 4 and 5 and LINE B 12 and 13 binding posts are for connecting the line or switchboard wires depending upon whether the repeater is used at an intermediate or terminal point.

(*2*) The EXT NET A 6 and 7 and EXT NET B 10 and 11 binding posts are for connecting external networks when required.

(*3*) The BAT binding posts +12, —, and +135 (numbered 1, 2, and 3, respectively) are for connecting the storage battery supply or dry cell batteries.

(*4*) The MON binding posts 8 and 9 are for connection to the monitoring receiver.

(*5*) The SX binding posts 4-5 and 12-13 are for d-c telegraph connections. Strapping these binding posts permits telegraph signals to pass through the repeater.

(*6*) The ARRESTER GROUND binding post 14 is for connection to the office ground.

(*7*) A power cord with plug termination extends through the panel for connection to the a-c supply.

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† 135-volt and 12-volt batteries used together for dry battery operation.

b. A soft rubber gasket between the box and cover permits the connecting wires and power cord to be brought out with the cover closed.

6. SWITCHES AND CONTROLS.

a. The BO-A and BO-B switches are each associated with a variable building-out capacitor and are used to vary the capacity as required by the length of entrance wire or cable.

b. The NET A-1, NET A-2, NET B-1, and NET B-2 switches are the balancing network control switches which are set to correspond with the various line facilities as covered in paragraph 2b.

c. The GAIN-AB and GAIN-BA switches are used for adjusting the gain of their respective amplifiers.

d. The EQL-AB and EQL-BA switches are provided to adjust the over-all frequency response of the system.

e. The VOLTAGE SELECTOR switch has four positions corresponding to the types of power supply which may be connected to the repeater.

f. The MON switch is used when monitoring on the circuit or when talking to either terminal.

g. The POWER switch is used to turn the power on or off.

7. PROTECTION.

Open space cut-out protectors are provided across each of the lines, located adjacent to the LINE A and LINE B binding posts. A binding post marked ARRESTER GROUND is provided for connecting the protectors to ground. This binding post is insulated from the panel and chassis of the repeater.

8. OPERATING AND CIRCUIT LABEL.

Condensed instructions for operating the repeater, as well as a schematic diagram and table of network settings, is mounted in the box cover. A reproduction of this label is shown in figure 21.

SECTION II

INSTALLATION AND OPERATION

9. LIMITATIONS.

The maximum gain which can be used in either direction in a two-wire repeater depends upon the over-all loss of the circuit, the balance between the line and network on each end of the repeater, the load carrying capacity of the vacuum tubes, crosstalk, noise, and other factors. Methods of determining the permissible gains are covered in paragraphs 27 and 28. In the instructions which follow, it is assumed that the operating gains of the repeater have been specified.

10. LINE REQUIREMENTS.

Successful operation of a two-wire repeatered circuit requires that the line sections between adjacent repeaters be regular in construction so that their impedance characteristics will be smooth. Regularity implies the use of the same gauge and spacing of wire throughout a repeater section and the absence of lengths of intermediate cable located at random points within the section. Before applying two-wire telephone repeaters to a line, make an inspection of the line condition to determine whether the regularity of the line appears satisfactory for the purpose. A discussion of the factors to be considered in judging the regularity of a line is given below.

a. Changes in gauge and spacing of the wire of an open wire pair more than a few miles from the ends of the repeater section may cause substantial irregularities in impedance and thus seriously impair the balance.

b. Lengths of entrance cable or wire located at the ends of a repeater section will also affect the impedance of the line. If not longer than the lengths given below, these cables can be balanced fairly satisfactorily by the building-out capacitor unit in the network. For this balance to be effective, however, it is essential that the characteristics of the cable or wire used in joining the repeater to the line proper be stable with respect to weather conditions so

that a suitable adjustment of the network will hold over a period of time. This restriction definitely excludes the use of unstable wire such as Wire W-110-B, Wire W-50, etc., for entrance cable except for very short lengths. The types and lengths of cable or wire which may be used for this purpose are:

(*1*) Single pairs in Cable Assemblies CC-368 (or salvaged cable from Cable Assemblies CC-358 with the connectors and loading coils removed) for lengths up to 1¼ miles.

(*2*) Wire W-143, nonloaded, for lengths up to 1 mile.

(*3*) Single pairs or phantoms in Cables CC-345 and CC-355 for lengths up to 1 mile.

c. If cables longer than the limiting lengths are used, two-wire repeater operation will be feasible in many cases but the balance will be degraded and allowance for this should be made in laying out the repeater sections.

d. Complete Cable Assemblies CC-358 cannot be used at or near the end of an open wire line because the balance will be very low. This facility can be used near the center of a repeater section but, in such cases, the balance may be considerably degraded.

e. In some cases where it is absolutely necessary to utilize Cable Assemblies CC-358 as long entrance cables for open wire circuits, Telephone Repeater TP-14 may be located at the open wire junction and a pair in the spiral-four cable used as a full repeater section. As an alternative, the spiral-four section may be operated on a four-wire basis by operating the repeaters at either end of that section as four-wire terminal repeaters as described in paragraph 23.

f. Accepted methods for the treatment of entrance and intermediate cables in open wire lines are described in TM 11-368.

11. REPEATER SPACING.

a. The repeater spacings and maximum circuit lengths which can be used with Telephone Repeater TP-14 as a 22-type telephone repeater are determined by the balance that can be realized between the line section and balancing network. The magnitude of the balance depends upon the accuracy of the setting of the balancing network switches and the smoothness of the impedance characteristics of the line. The latter will be high when the construction of the line is very uniform, thus permitting a high bal-

ance. On the other hand, if the line involves changes of gauge and spacing of wires and includes intermediate cable, there are likely to be impedance irregularities and the balance which can be obtained may be quite low.

b. It is often necessary for layout purposes to make some estimate of the balances which can be obtained before repeaters are applied to the circuit. Some appropriate rules for making such estimates are given in paragraph 29.

12. LOCATION OF REPEATER.

a. The approximate location of the repeaters in a telephone circuit is primarily dictated by the type of wire facilities of which the line is constructed. Repeaters are customarily spaced at equal intervals when the line is of uniform construction throughout. When terminal repeaters are used at both ends of the circuit, one less intermediate repeater is required. This may be an advantage from the standpoint of maintenance and control.

b. If major discontinuities in line impedance are present, such as a junction between long sections of open wire and loaded cable, a repeater must be placed at this point regardless of any other considerations.

c. Another factor bearing on the location of a repeater is the availability of electric power. Advantage should be taken of any location with a-c power, otherwise it will be necessary to service the repeater with 12-volt storage batteries or dry cell batteries with the attendant supply problems.

13. UNPACKING THE REPEATER.

Telephone Repeater TP-14 is shipped in an individual wooden shipping case, the unit being wrapped in waterproof liners and vaporproof foil-coated barriers and secured by steel straps to a pallet which is bolted to the inside bottom of the case. Be careful in handling the equipment before and after unpacking to prevent any unnecessary shocks.

a. With the case resting on its skids, remove the nails which hold the sides and ends to the bottom of the case.

b. Cut the steel bands from the case and lift the case carefully from the unit.

c. Cut the steel bands which secure the unit to the pallet.

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d. Remove the wrappings of waterproof paper, corrugated paper, and foil-coated barrier, and remove the unit from the pallet.

14. PREPARATION FOR USE.

a. Installing the Repeater. Select a sheltered location as free from vibrations as possible and accessible to the power supply and remove the outer case cover. If the repeater is to be rack mounted, remove the four screws at each end of the panel and lift the unit from the case. Attach the end brackets, which are clamped in the bottom of the case, to the unit, using the eight No. 10 screws which are inserted in the chassis frame below the panel. Mount the unit on the rack using the eight No. 12 screws removed from the panel.

b. Preliminary Checks and Adjustments.

(*1*) Remove the chassis and panel assembly from the case and remove the dust cover.

(*2*) Check to see that vacuum tubes and vibrator are firmly seated in their sockets.

(*3*) Tighten any loose screws and nuts.

(*4*) Check to see that soldered connections to terminals are tight.

(*5*) Restore the dust cover and replace the unit in the case.

15. GROUND CONNECTION.

A low-resistance ground is required at each repeater station to minimize hazard to the equipment and personnel from lightning and other sources of high voltage. For methods of obtaining a good ground source, refer to TM 11-755.

16. CONNECTION OF POWER SOURCE.

a. A-c Operation. When 110/130-volt or 220/250-volt, 50- to 60-cycle alternating current is available, connection to the source is made by means of the power cord provided with the equipment. Set the VOLTAGE SELECTOR switch in position 115 or 230 depending upon the voltage of the local supply.

b. 12-Volt Storage Battery Operation. When operation is desired from 12-volt storage batteries, connect two 6-volt (two Batteries BB-55, or equivalent, connected in series) or one 12-volt storage battery (Battery BB-50, or equivalent) to the BAT binding

posts +12 and —, also designated as 1 and 2. Make sure that the positive terminal of the battery is connected to the +12 binding post. Use No. 12 gauge or larger heavy insulated copper wire for connecting the battery and keep the leads as short as practicable, preferably not over 3 feet in length. *Do not use Wire W-110-B for this purpose.* Set the VOLTAGE SELECTOR switch in position 12.

c. External Dry Battery Operation. The repeater can be operated from any external batteries of the proper voltage which may be at hand, if no other source is available. Two groups of batteries are required; a 12-volt battery (eight Batteries BA-23, or equivalent, connected in series) for heater supply, and a 135-volt battery (three Batteries BA-26, or equivalent, connected in series) for plate and screen supply. Use heavy insulated copper wires for making connections to the batteries, particularly the 12-volt battery.

(*1*) Set the VOLTAGE SELECTOR switch on position EXT.

(*2*) Connect the positive terminal of the 135-volt battery to the +135 BAT binding post, also designated 3. Connect the negative terminal of the 135-volt battery to the negative of the 12-volt battery and to the — binding post, designated 2. Connect the positive terminal of the 12-volt battery to the +12 binding post, designated as 1.

> **CAUTION:** To prevent damage to the filter capacitors in the repeater, do not connect the 12-volt battery supply with reversed polarity.

17. PRELIMINARY CHECK OF REPEATER.

a. Ground Connection. Connect the office ground to the ARRESTER GROUND binding post.

b. Power Connection. Check to see that the power source is connected in the proper manner and that the VOLTAGE SELECTOR switch is set to correspond with the type of power being supplied. Throw the POWER switch to position ON.

c. Total Gain Check for Repeater.

(*1*) Turn the GAIN-AB and GAIN-BA switches to position X; turn the EQL-AB and EQL-BA switches to position 1; turn the BO-A and BO-B switches to position 12; turn the NET A-1 and NET B-1 switches to position 11; and turn the NET A-2 and NET B-2 switches to position 15.

(*2*) Connect the monitoring receiver to the MON binding posts.

(*3*) Turn the GAIN-AB and GAIN-BA switches to position 0. Listen in the monitoring receiver for singing and advance one or alternately both of these switches until singing is heard.

NOTE: The repeater should sing with the GAIN-AB and GAIN-BA switches set on position 0 or 2. If singing does not occur, check the A-B and B-A transmission paths separately as follows:

d. Repeater Gain Check by Separate Paths.

(*1*) Set the NET A-1 switch on position 11 and the NET A-2 switch on position 15.

(*2*) Strap the SX binding posts 4-5 and 12-13.

(*3*) Set both the GAIN-AB and GAIN-BA switches on position X.

(*4*) Set both the EQL-AB and EQL-BA switches on position 1.

(*5*) Strap LINE A binding post 5 to LINE B binding post 12 and strap LINE A binding post 4 to LINE B binding post 13.

(*6*) Turn the GAIN-AB switch slowly clockwise, listening in the receiver for singing and note the switch setting at which singing starts. Restore the switch to position X.

(*7*) Repeat the above operation using the GAIN-BA switch.

(*8*) If singing does not occur with the GAIN-AB and GAIN-BA switches on 0 or 2, the vacuum tubes or batteries may need replacement or the repeater may require servicing.

(*9*) Remove the straps between the LINE A and LINE B binding posts.

18. INSTALLATION AND ADJUSTMENT.

a. Intermediate Repeater.

(*1*) Connect the lines from direction A to LINE A binding posts 4 and 5 and connect the lines from direction B to the LINE B binding posts 12 and 13.

(*2*) Set the NET A-1, NET A-2, NET B-1, NET B-2, EQL-AB, and EQL-BA switches in accordance with the particular line facilities as covered in table I below.

(*3*) If the equalizer switch settings are not covered in the table or not otherwise specified, both equalizer switches should be set temporarily on position 1.

(*4*) Set the GAIN-AB and GAIN-BA switches to correspond with the gains specified for each direction of transmission. If no gain settings have been specified, advance the GAIN-AB and GAIN-BA switches alternately one step at a time to the right until singing is heard in the monitoring receiver, then reduce the gain setting of each switch by two steps to provide singing margin.

(*5*) Make a listening test to insure adequate singing margin.

b. Terminal Repeater.

(*1*) Connect the outgoing line or cable to either the LINE A binding posts 4 and 5 or the LINE B binding posts 12 and 13.

(*2*) Set the corresponding NET A-1 and NET A-2 or NET B-1 and NET B-2 switches in accordance with the outgoing facility as determined from table I.

(*3*) Connect the other set of line binding posts to the switchboard circuit.

(*4*) Set the corresponding NET A-1 or NET B-1 switch on position 10 and the NET A-2 or NET B-2 switch on position 15.

(*5*) Set the equalizer switch corresponding to the switchboard end on position 1 and the other equalizer switch on the position corresponding to the outgoing wire or cable facility.

(*6*) Adjust the GAIN-AB and GAIN-BA switches as described in subparagraphs **a** (*4*) and **a** (*5*) above.

c. Building-out Capacitors. The building-out capacitor provided with each balancing network is not required and should be set on position 12 unless a short length (not exceeding approximately 1 mile) of nonloaded entrance cable intervenes between the repeater and an adjacent main line section. When such is the case, an approximate setting of the BO-A or BO-B switch as required, may be made on the basis of one step of the switch for each 500 feet of entrance cable. This adjustment must thereafter be refined by performing a balance test, at which time it can be set to produce a maximum singing point. Otherwise, the use of the BO-A and BO-B switches is entirely independent of the settings of the other network switches.

d. External Line-balancing Network.

(*1*) External line-balancing networks are required in order to obtain sufficiently good balance if a type of line other than those for which the repeater is designed, is connected to either or both

ends of the repeater. This network should include a 2-microfarad capacitor to balance the 2-microfarad capacitor connected in series with the line windings of repeating coil T2A (or T2B).

(*2*) Connect the external balancing network to the EXT NET A binding posts 6 and 7 or EXT NET B binding posts 10 and 11 or both as required.

(*3*) Set the NET A-1, NET A-2 (or NET B-1, NET B-2) switches on positions 10 and EXT respectively.

e. Detailed Operating Procedure.

(*1*) Adjust the NET A-1, NET A-2, NET B-1, NET B-2, EQL-AB, and EQL-BA switches according to settings listed in the following table.

TABLE I. NETWORK AND EQUALIZER ADJUSTMENTS

	Network switches		
Facility	*NET A-1 or B-1*	*NET A-2 or B-2*	*Equalizer AB or BA*
0.104 copper, 8″ side	3	16	1
0.104 copper, 8″ phantom	2	10	1
0.104 copper, 12″ side	3	16	1
0.104 copper, 12″ phantom	2	10	1
0.128 copper, 12″ side	2	15	1
0.128 copper, 12″ phantom	1	10	1
0.165 copper, 12″ side	2	15	1
0.165 copper, 12″ phantom	1	7	1
0.080 cu-steel, 40%, 8″ side	8	13	1
0.104 cu-steel, 40%, 8″ side	6	15	2
0.104 cu-steel, 40%, 8″ phantom	4	10	1
0.104 cu-steel, 40%, 12″ side	6	16	2
0.104 cu-steel, 40%, 12″ phantom	4	10	1
0.109 steel, 12″ side	9	20	2
W-110-B on insulators, 12″ metallic phantom	9	15	1

W-110-B nonloaded on ground, wet	6	6	3
W-110-B nonloaded on ground, damp	7	4	3
W-110-B nonloaded on ground, dry	7	6	3
W-110-B loaded 5,280-88, wet	3	16	1
W-110-B loaded 5,280-88, damp	3	20	1
W-110-B loaded 5,280-88, dry	4	22	1
W-143 nonloaded	3	3	3
W-143 loaded 3,300-44	1	13	3
WC-534 pair, nonloaded	5	4	3
CC-358 pair, loaded 1,320-6	2	12	1
16 or 19 ga cable, loaded 6,000-88 side	3	22	1
16 or 19 ga cable, loaded 6,000-50 phantom	2	16	1
16 or 19 ga cable, loaded 6,000-44 side	3	19	1
16 or 19 ga cable, loaded 6,000-25 phantom	1	13	1
Switchboard or Telephone EE-8-( ) (at a terminal repeater)	10	15	1

NOTE 1: Figures in inches indicate the nominal spacing of the wires in an open wire pair.

NOTE 2: In loaded circuits, the first figure indicates loading coil spacing in feet and the second figure gives the inductance of the loading coils in millihenrys.

NOTE 3: The words "side" and "phantom" designate side and phantom circuits respectively.

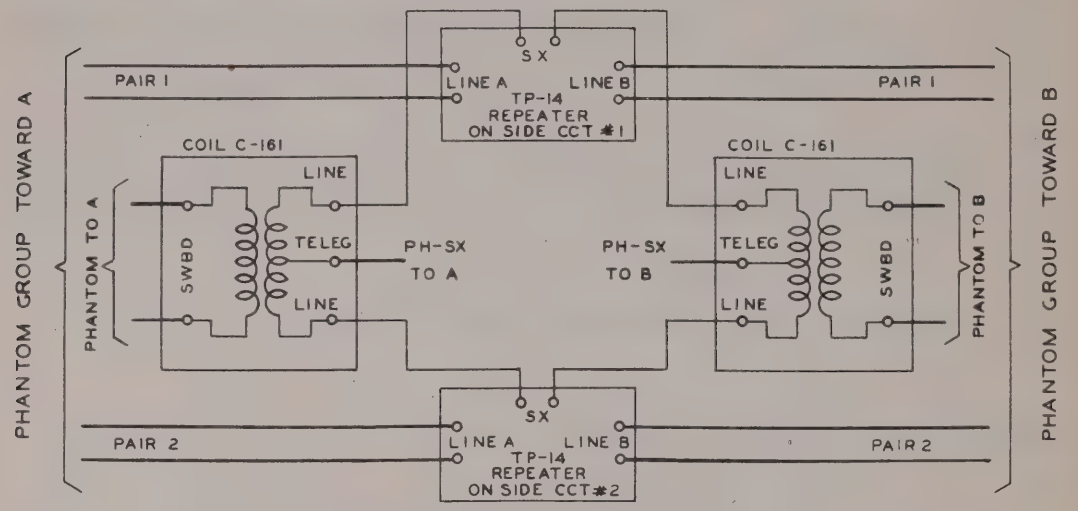
NOTE 4: In some cases it may be necessary to set the NET A-2 or NET B-2 switch at a position other than that specified above to improve the balance.

(*2*) Adjust the GAIN-AB and GAIN-BA switches as specified. (The gain is adjustable in 10 steps of 2 db each with an additional step X which disables the amplifier.)

(*3*) Connect the receiver to the MON binding posts 8 and 9 and listen for singing. Follow the procedure described in subparagraph (*a*) or (*b*) below, whichever is applicable.

(*a*) If the repeater does not sing, turn the GAIN-AB and GAIN-BA switches to the right one step and again listen for singing. If the repeater does not sing at this point, return the GAIN switches to their specified positions. If the repeater does sing, reduce each GAIN switch one step below its specified value.

(*b*) If the repeater sings, turn the GAIN-AB and GAIN-BA switches to the left, alternately, one step until the singing stops. Then decrease each GAIN switch one step.



TELEPHONE REPEATERS ON SIDE CIRCUITS ONLY
PHANTOM-SIMPLEX IN EACH DIRECTION
DROPPED AT REPEATER

NOTES:
FOR THROUGH PHANTOM-SIMPLEX, STRAP TELEG BINDING POSTS OF BOTH COILS C-161.
FOR THROUGH PHANTOM, CONNECT SWBD BINDING POSTS OF BOTH COILS C-161.
FOR THROUGH PHANTOM AND PHANTOM-SIMPLEX, OMIT COILS C-161 AND STRAP SX BINDING POSTS OF EACH REPEATER.

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Figure 4. Phantom group repeater layout, side circuit repeaters.

19. SIMPLEX AND PHANTOM CONNECTIONS.

a. The simplex circuit is connected through the repeater normally by the strap between the SX binding posts 4-5 and 12-13. If the simplex circuit from either the A or B direction is to be terminated in equipment at the repeater point, connect the equipment to the SX binding post 4-5 or 12-13 as required and remove the strap between the SX binding post.

b. If two Telephone Repeaters TP-14 are installed at the same location on two pairs forming a phantom group (fig. 4), the phantom may be carried through or dropped in the same manner as the simplex circuits referred to above. As such, the simplex path through each repeater comprises one leg of the phantom. The phantom coils provided in the equipment are specially shielded to permit dropping the phantom circuit at a repeater without exces-

sive phantom-to-phantom crosstalk on the two sides of the repeater. The phantom circuit may be simplexed for telegraph operation by using a Coil C-161 at each terminal. At any intermediate point, the repeater and/or the phantom-simplex may be carried through or dropped independently.

c. Several other variations of phantom group arrangements are possible for various types of service, some of the more common of which are shown in figure 5 (A), (B), and (C).

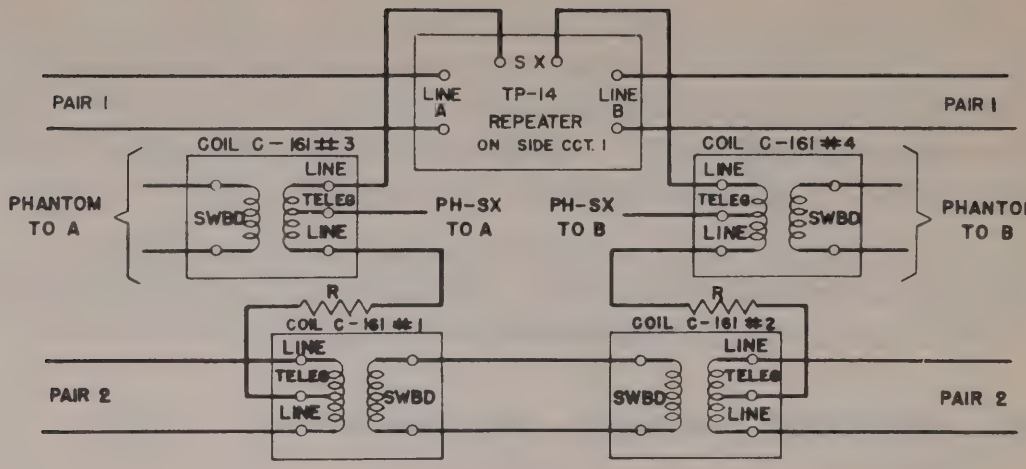
20. MONITORING, TALKING, AND SIGNALING.

a. Monitoring. A single head receiver is supplied with the repeater which, when not in use, is retained in a convenient location on the panel by means of spring clips. Ordinarily, the receiver cord will be connected to the MON binding posts 8 and 9. This connection may be left permanently without adversely affecting the operation of the repeater. The receiver will be instantly available for use in monitoring the circuit established through the repeater, since no switch operation is necessary to monitor. Monitoring is effected through the association of the receiver with special windings on both hybrid coils so that communication in both directions may be heard with equal facility.

b. Talking. To talk from a repeater station, it is necessary to connect a Telephone EE-8-( ) to the MON binding posts 8 and 9. The monitoring receiver need not be disconnected from the repeater. Communication with adjacent points along the telephone circuit can be established by operating the MON switch in the appropriate direction as indicated by the panel markings. Keep the butterfly switch on the handset operated while talking. For listening to the reply, release the butterfly switch on the handset and the MON switch on the panel. The talking arrangement thus provided connects the Telephone EE-8-( ) to the output circuit of either of the one-way amplifiers as determined by the position of the MON switch.

c. Signaling. Ordinary 20-cycle signaling currents are bypassed through the repeater. Passage of a ring can be detected by the monitoring operator but no means is available for receiving a ringing signal at a repeater point, even though a Telephone EE-8-( ) may be connected to the MON binding posts.

> **CAUTION:** Do not attempt to ring from a telephone connected to the MON binding posts as described above. If it



TELEPHONE REPEATER ON ONE SIDE CIRCUIT ONLY

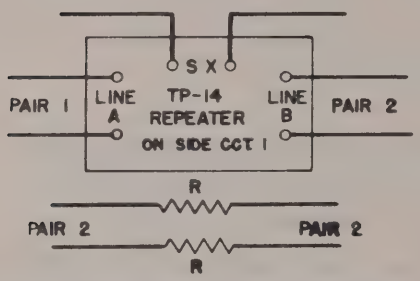
WITH PHANTOM AND PHANTOM-SIMPLEX IN EACH DIRECTION DROPPED AT THE REPEATER POINT WITH COMPENSATING RESISTORS IN PHANTOM LEG OF NON-REPEATERED SIDE CIRCUIT TO MAINTAIN PHANTOM BALANCE.

NOTE 1: FOR THROUGH PHANTOM-SIMPLEX, STRAP TELEG BINDING POSTS OF TWO COILS C-161, #3 & #4

NOTE 2: FOR THROUGH PHANTOM, CONNECT TELEG BINDING POSTS OF TWO COILS C-161, #1 & #2, THROUGH A RESISTANCE OF VALUE 2R OHMS. STRAP SX BINDING POSTS

NOTE 3: EACH RESISTOR R TO BE APPROX. 65 OHMS, WIRE WOUND, 1/2 WATT OR GREATER

(A)

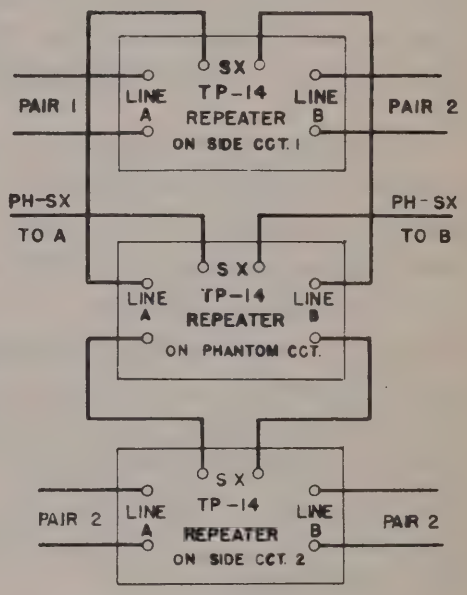


TELEPHONE REPEATER ON ONE SIDE CIRCUIT ONLY

HAVING PHANTOM AND PHANTOM-SIMPLEX CARRIED THROUGH WITH COMPENSATING RESISTANCES IN OTHER SIDE CIRCUIT TO MAINTAIN PHANTOM BALANCE

NOTE: R = APPROX. 200 Ω, WIRE WOUND, 1/2 WATT, RESISTORS MATCHED TO WITHIN 2 OHMS.

(B)



TELEPHONE REPEATERS ON BOTH SIDE CIRCUITS AND PHANTOM

WITH PHANTOM SIMPLEX IN EACH DIRECTION DROPPED AT THE REPEATER.

NOTE: FOR THROUGH SIMPLEX, STRAP S X BINDING POSTS ON PHANTOM CCT REPEATER

(C)

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Figure 5. Typical phantom group repeater arrangements.

is necessary in an emergency to signal from a repeater station, either terminal can be reached by momentarily turning the repeater off (by means of the POWER switch), connecting a Telephone EE-8-( ) to the LINE A 4 and 5 or LINE B 12 and 13 binding posts, and then ringing. The corresponding terminal of the circuit should respond and a normal conversation can be carried on over that portion of the circuit between repeater and terminal regardless of intervening repeaters.

21. REPEATER BALANCE TEST.

a. Definition. In all practical cases, at each terminal of a 22-type repeater, a portion of the output current is fed back into the repeater. If these returned currents are too strong, the repeater may sing. The relation between the output current and the returned current at each end of a repeater depends upon the similarity between the impedance of the line and its balancing network and is different at different frequencies. The measure of the ratio of returned current to output current may be expressed in decibels (db) and is called the balance or singing point. In the practical case, this quantity is measured by setting up the repeater as a measuring instrument and adjusting the GAIN-AB and GAIN-BA switches until a sing is heard in the monitoring receiver. The resultant settings of the GAIN switches are added to give a figure for the balance in db. The balance is of particular significance in determining the useful gain which can be obtained from a repeater in service, as well as an indication of trouble appearing on the lines associated therewith. The method of measuring balance is described below.

b. Measurement. The balance between a line and its balancing network is measured as follows. It should be noted that this test can be made only when the repeater and the line are not in use.

(*1*) *Balance Between Line A and Network A.*

(*a*) Check to see that the NET A-1, NET A-2, and EQL-AB switches are in their normal working positions.

(*b*) Set NET B-1 and NET B-2 switches on position 10 and 15, respectively, and EQL-BA switch on position 1. Check to see that the BO-B switch is in position 12.

(*c*) Set the GAIN A-B and GAIN B-A switches on position X.

(*d*) Disconnect the line wires from the LINE B binding posts 12 and 13.

(*e*) Listen in the monitoring receiver and increase the settings of the GAIN-AB and GAIN-BA switches alternately one step at a time until the repeater just sings. Decrease the gain setting of one or the other GAIN switches by one step. Note the sum of the two lowest GAIN switch settings upon which singing just continues.

(*f*) Repeat the operations covered by subparagraph (*e*) above with the LINE B binding posts 12 and 13 short circuited.

(*g*) The smaller of the two sums determined by tests in subparagraphs (*e*) and (*f*) above is the approximate balance in db between line A and its corresponding network A.

(*2*) *Balance Between Line B and Network B.*

(*a*) Check to see that the NET B-1, NET B-2, and EQL-BA switches are in their normal working positions.

(*b*) Set NET A-1 and NET A-2 switches on position 10 and 15, respectively, and EQL-AB switch on position 1. Check to see that the BO-A switch is in position 12.

(*c*) Set the GAIN-AB and GAIN-BA switches on position X.

(*d*) Disconnect the line wires from the LINE A binding posts 4 and 5.

(*e*) Listen in the monitoring receiver and increase the settings of the GAIN-AB and GAIN-BA switches alternately one step at a time until the repeater just sings. Decrease the gain setting of one or the other GAIN switches by one step. Note the sum of the two lowest GAIN switch settings upon which singing just continues.

(*f*) Repeat the operations covered by subparagraph (*e*) above with the LINE A binding posts 4 and 5 short circuited.

(*g*) The smaller of the two sums determined by tests in subparagraphs (*e*) and (*f*) above is the approximate balance in db between line B and its corresponding network B.

NOTE: At the conclusion of operations described in subparagraphs (*1*) and (*2*) above, be sure that all connections and switch settings are returned to normal.

22. USE AS A 21-TYPE REPEATER.

a. If desired, Telephone Repeater TP-14 can be used as a 21-type repeater when the same type of wire facility is connected in either direction. For this service, the networks are not used. The line wires from direction A are connected to the LINE A binding posts 4 and 5 and the line wires from direction B are connected to the EXT NET A binding posts 6 and 7. The NET A-1 switch is set on position 10 and the NET A-2 switch is set on position EXT. The NET B-1 and NET B-2 switches are both set on position EXT and a strap is connected between the EXT NET B binding posts 10 and 11. No connection is made to the LINE B binding posts.

b. The connection of the repeater, which is shown schematically in figure 6, effectively uses only one hybrid arrangement and connects the two amplifiers and their associated equalizers in tandem by converting the repeating coils in the B side of the repeater into a simple transformer.

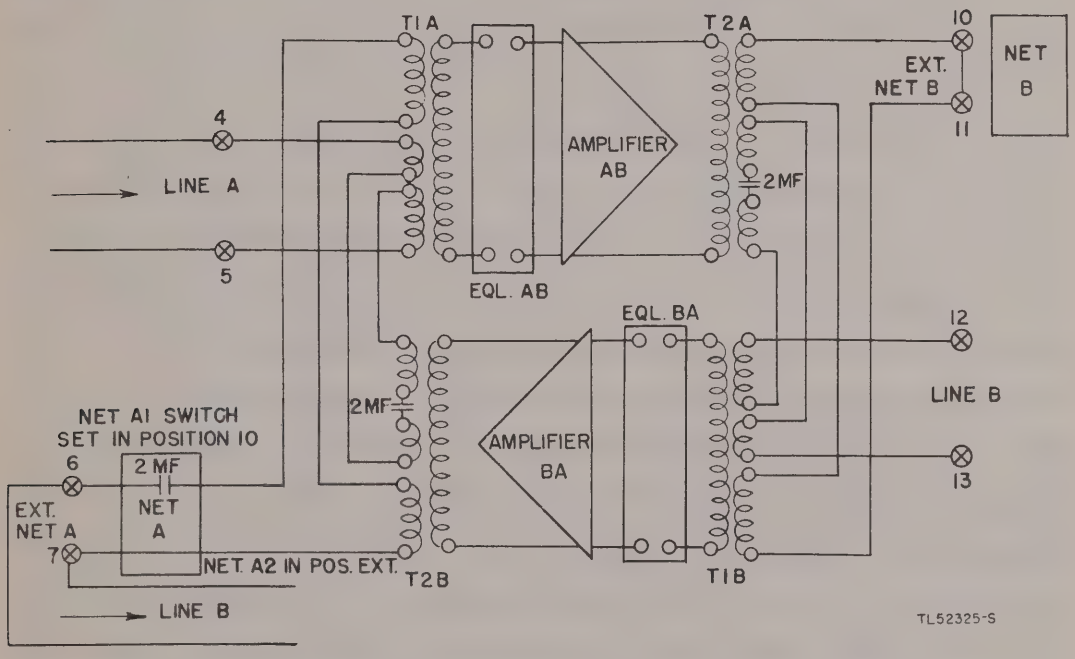


Figure 6. Telephone Repeater TP-14, used as a 21-type repeater.

c. When used in this manner, 20-cycle signaling over the circuit cannot be used and voice-frequency ringing must be used. Furthermore, with this connection, there will be no protector blocks across the line connected to the EXT NET A binding posts 6 and 7.

d. The gain which can be used depends upon the balance between the two lines connected to the repeater. Under favorable circumstances, a gain of about 16 db should be obtained with ade-

quate singing margin. For further information as to the proper application of 21-type repeaters, refer to TM 11-2006, describing Telephone Repeater EE-89-A.

e. Since the two amplifiers in this case are connected in tandem, it is suggested that the GAIN-AB switch be set at position 0 and the EQL-AB switch be set at position 1, whereupon the BA amplifier will provide the gain and equalization required. The EQL-BA switch should be set for the type of lines being used as indicated in table I, and the GAIN-BA switch should be adjusted while monitoring and set two steps below the point at which singing just occurs.

23. USE AS A FOUR-WIRE REPEATER.

a. General. Telephone Repeater TP-14 can also be used as a four-wire repeater. Two arrangements are possible; either two separate repeater units can be used, one in each side of the four-wire circuit as described in subparagraph **b** below or the arrangement described in subparagraph **c** below which utilizes only one repeater at a given location. When the former arrangement is used, a four-wire terminating set is required at each end of the four-wire circuit, such as a Telephone Repeater EE-99-A (see TM 11-348), or one Telephone Repeater TP-14 using the connection outlined in paragraph 24 must be used at each terminal to provide a two-wire termination. In general, the arrangement using only one repeater unit at each location is recommended since it minimizes the types and quantity of equipment required.

b. Arrangement Using Two Repeater Units. Where two repeater units are used for four-wire service, only one-half of one repeater is used for transmission in one direction and one-half of the other repeater for transmission in the opposite direction. The unused halves of each repeater unit are rendered ineffective by turning the proper GAIN switch to position X. With this arrangement, the gain which can be obtained is not limited by balance, and any value of gain up to the maximum available in the repeater can be used, provided the net loss is not lower than 3 db on the four-wire circuit under all weather conditions. The connections for each repeater are the same as when the repeater is used in a two-wire circuit except that the GAIN switch is turned to position X for the direction of transmission opposite to that for which the repeater is used in the four-wire circuit. The network and equalizer switches are set as for a two-wire repeater and the GAIN switch corresponding to the direction of transmission being passed is

adjusted as required. The repeater gain for this arrangement is the same as when the repeater is used in a two-wire circuit so that the maximum 1,000-cycle gain is of the order of 18 db. The arrangement will provide a simplex and 20-cycle path through each repeater.

c. Single Repeater Arrangement. The arrangement using only one repeater can be used at either a terminal or an intermediate location. The maximum gain which can be obtained for this type of four-wire connection will be limited in some cases by the balances between the two lines on the same side of the repeater. The poling of each pair must be carefully checked since, if the line wires are not poled correctly, little or no gain will be obtained because the currents transmitted over one pair may cancel those transmitted over the other pair, instead of aiding them. With this arrangement, one line of the four-wire circuit is connected to the EXT NET binding posts, hence there will be no protector blocks associated with this line.

(*1*) *Intermediate Repeater.*

(*a*) The connections to be used for a four-wire intermediate repeater are as follows: Disassociate both networks from the repeater but leave the two-microfarad capacitors in the network circuits by throwing NET A-1 and NET B-1 switches to position 10 and NET A-2 and NET B-2 switches to EXT. Connect line 1 from the A direction to binding posts LINE A (4 and 5) and line 1 from the B direction to binding posts LINE B (12 and 13). Connect line 2 from the A direction to binding posts EXT NET A (6 and 7) and line 2 from the B direction to binding posts EXT NET B (10 and 11). These connections will be clear by referring to figure 7. The wires connected to binding posts LINE and EXT NET on the same side of the repeater must then be poled correctly. The proper poling for each pair is accomplished by listening on the monitor receiver of the repeater to a person talking at one end of the circuit. While listening, *with both GAIN switches set at X,* reverse the two wires connected to the line binding posts on that side of the repeater facing the talker. Determine which poling of these wires produces the *least* volume in the receiver and connect the wires permanently for that condition. This test should be repeated at each excessive repeater along the line beginning with the intermediate repeater nearest the talker. If the poling adjustment is correct for one direction of transmission, it will be correct for the opposite direction.

(*b*) The net gain which can be realized from a repeater under this condition will be limited only by the balances obtainable. On nonloaded Wire W-110-B, the maximum useful gain is about 14 db. This will be increased somewhat for higher impedance facilities.

(*c*) With this arrangement both a simplex and a 20-cycle path will be available over line 1 but neither will be available over line 2.

(*2*) *Terminal Repeater.* The repeater can also be used in a four-wire circuit as a terminal repeater. In this case, only one end of the repeater is connected to a four-wire connection, whereas the opposite end remains a normal two-wire connection using a network to balance the switchboard, telephone, or extended two-wire line. The outgoing four-wire line 1 is connected to one pair of line binding posts, such as LINE A, and line 2 is connected to the corresponding external network binding posts, such as EXT NET A. In this case, the switchboard, telephone, or two-wire line is connected to binding posts LINE B. Switch NET A-1 is set on position 10, switch NET A-2 is set on EXT and switches NET B-1 and NET B-2 are set to balance the circuit connected to binding posts LINE B in accordance with table I. This connection will complete the necessary circuit arrangements to permit 20-cycle ringing and simplex telegraphy over the entire circuit, via line 1, from terminal to terminal, including the extended two-wire facility, if any.

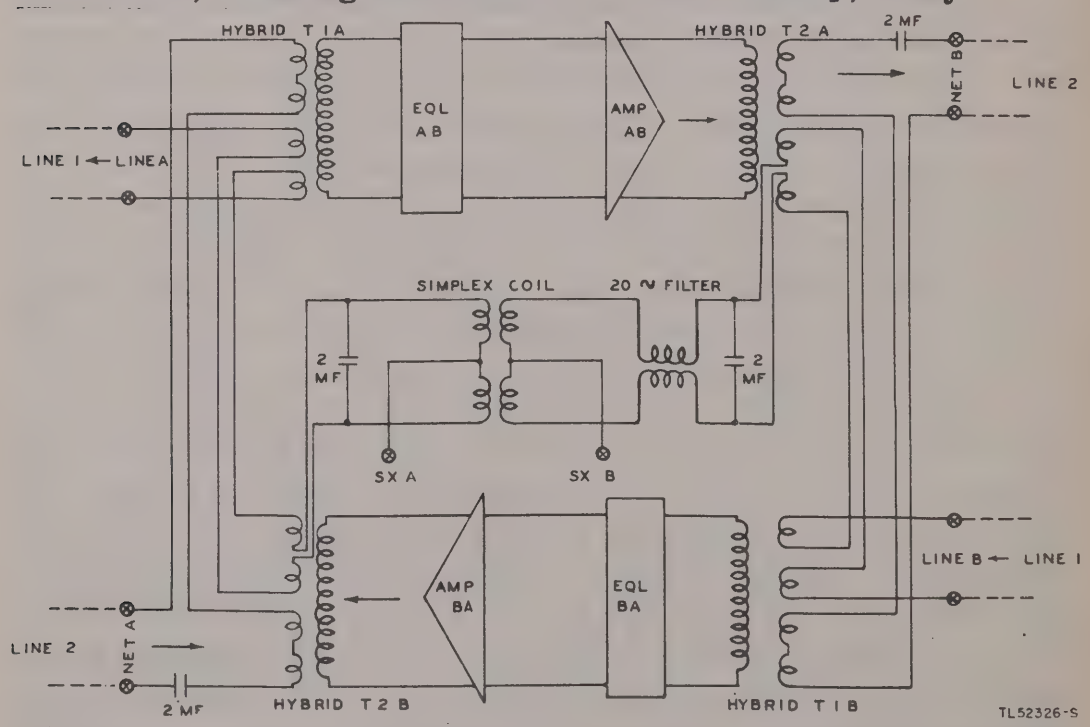


Figure 7. Telephone Repeater TP-14, used as a four-wire repeater.

(*3*) *Adjustments.* When the repeater is used as a four-wire repeater in any of these arrangements, all equalizers should be adjusted in accordance with table I. The GAIN switches should be set as determined by computation so that each repeater gain compensates for the loss in the four-wire line sections on either side of it, or adjusted by increasing the GAIN switches equally all along the line, then reducing each switch at least one step. When adjusting the GAIN switches it should be remembered that, with this connection, the actual repeater gain in each direction is 6 db greater for an intermediate repeater and 3 db greater for a terminal repeater than indicated by the switch settings. The active singing margin as measured at each repeater individually should represent at least two gain steps when the circuit is completely lined up. Care should be taken, also, that the output level of each terminal repeater is satisfactory from the overload standpoint, as determined by observing the quality of speech received at the adjacent intermediate repeater.

24. USE AS A TWO-WIRE—FOUR-WIRE INTERCONNECTING REPEATER APPLIED TO RADIO LINK.

a. A Telephone Repeater TP-14 can be used to provide a means for connecting a two-wire line, switchboard, or telephone set to a four-wire line or radio link terminal. Figure 8 shows the application to a radio link where, in order to properly modulate the radio transmitter, it is necessary to provide a moderate amount of amplification to compensate for the transmission loss encountered in a two-wire line.

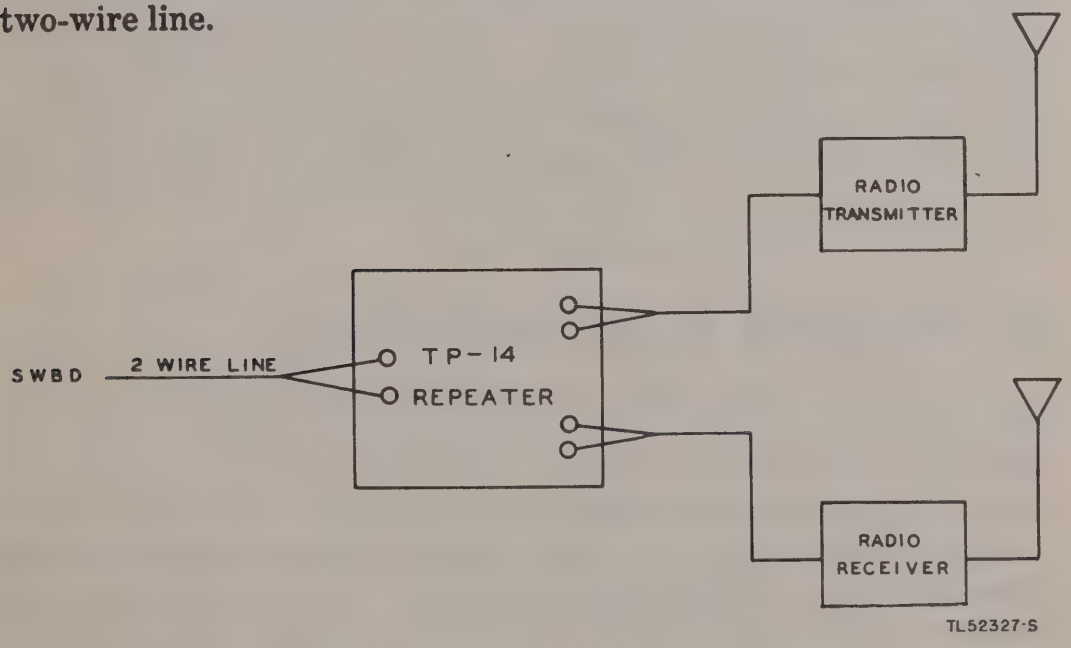


Fig. 8. Telephone Repeater TP-14, two-wire to a four-wire line or radio link.

b. The method used in setting up the repeater is the same as that described in paragraph 22. It is immaterial whether the EXT NET and LINE binding posts on the four-wire side of the repeater connect to the radio transmitter and receiver, respectively, as shown in figure 8 or vice versa.

c. The gain obtainable in this connection is limited by the balance which exists between the impedances looking into the transmitter input and receiver output, respectively, over the entire voice-frequency band. The most favorable conditions will be obtained when each of these impedances is resistive and equal to approximately 600 ohms. The gain will also be limited by the balance between the two-wire line and the network as when the repeater is used as a 22-type repeater.

d. Unlike the case of the terminal four-wire repeater described in paragraph 23c(*3*) above, the gain of the repeater in this connection will be as indicated by the GAIN switch setting, *not* 3 db more.

25. USE WITH LOADED FACILITIES.

For those cases where a repeater is to be used with a loaded line, networks have been provided to match what is called a mid-section termination. This means that the nearest loading coil should be one-half a loading section away from the repeater. Actually, some tolerance is permissible in that the repeater may be located at any distance greater than a half-section from the nearest load coil providing the building-out capacitor is used to add a capacity across the networks equal to the additional cable capacitance in excess of the value for one-half a section. The required value of building-out capacity is best determined experimentally in the course of making a balance test by adjusting the capacity by means of the switch BO to obtain the highest balance.

26. MAINTENANCE OF REPEATERED CIRCUITS.

a. General. Trouble may occasionally develop after a repeatered circuit is set up and adjusted initially. Such trouble will ordinarily result either from line trouble or trouble at an individual repeater and will usually require immediate attention. Some of the more common troubles together with suggested remedial measures are discussed below. Before making detailed tests, however, each line section should be checked for continuity and the network, equalizer, and GAIN switch settings at each repeater should be verified

to insure that they are in accordance with the instructions for the facilities involved and have not been tampered with.

b. Singing. One of the troubles which may occur on a repeatered two-wire circuit is singing. Singing may be caused by improper gain layout of the circuit or by trouble in the line or repeaters. The cause of a singing condition can usually be located by the following procedure:

(*1*) Reduce the gain of the first repeater until singing just stops. Note the amount of the gain reduction and then restore the GAIN switches to normal. Repeat the observations at each repeater in the circuit in turn.

(*2*) If the gain has to be reduced about the same amount at all repeaters in order to stop the singing, or if singing cannot be stopped by this procedure at any one of the repeaters, the probabilities are that the circuit has been laid out with too much gain and that singing is occurring because of the low net loss of the over-all circuit without a definite trouble condition existing at one point. In such cases, the repeater gains should be reduced enough to obtain approximately equal singing margins at all repeaters.

(*3*) If the reduction in gain necessary to prevent singing is much larger at one repeater than at the other repeaters in the circuit, a trouble probably exists at that repeater. Balance tests should then be made in each direction from the repeater in trouble as described in paragraph 21b. If the balance test on one side of the repeater is much lower than that on the other side and is much lower than the values given in table I, a trouble condition exists on the side of the repeater with the low balance.

(*4*) In cases where the lines on the two sides of the repeater are of the same type, a location of the trouble as between the line and the repeater can be made by interchanging the lines on the two ends of the repeater so that the line on the A end is connected to the B end of the repeater and vice versa. If the abnormally low balance follows the line when this change is made, the trouble is in the line, whereas if the low balance test is obtained on the same side of the repeater, the trouble is in the repeater. In the latter case, it will be necessary to replace the repeater and examine it subsequently for loose or broken connections or defective apparatus.

c. Loss of Volume.

(*1*) The loss of volume in a repeatered circuit can, in general, be attributed to wire trouble, loss of gain at one or more repeater points, or to improper layout of the circuit. This type of trouble can usually be located by talking and monitoring on the circuit. If the net loss from end to end is much greater in one direction than in the other, trouble is likely to be in a repeater but if the net loss is high in both directions of transmission, the trouble may be in either a repeater or in the line. If the net loss is abnormally high, the trouble can be sectionalized by monitoring at each repeater in turn and noting in which section the large volume loss appears to occur.

(*2*) It will be appreciated that on normally high net loss circuits there will be a gradual decrease in volume from one end of the circuit to the other, even when conditions are normal and this is not an indication of trouble. Also, the volume in the A to B direction may be materially different from the volume in the B to A direction without a trouble condition existing, especially if the repeater is located at or near one end of the circuit.

(*3*) If the trouble is located at a repeater, the settings of the various switches should be checked. If these are normal, the repeater gain should be checked as described in paragraph 18e(*3*). If the measurements indicate low gain, the trouble may possibly be corrected by changing a tube or checking battery voltages in case storage or dry batteries are being used.

(*4*) When nonloaded Wire W-110-B is used, circuits will vary widely between wet and dry weather conditions and it will be necessary to make frequent adjustments of network settings and gain in order to maintain a satisfactory working circuit.

d. Noise and Crosstalk. Excessive noise and crosstalk are likely to occur when one side of the repeater is grounded or is unbalanced to ground with respect to the other side. Such a condition may result from actual trouble on the line itself or occasionally from dirty or grounded protector blocks in the repeater. In some cases, there may be no definite trouble condition and it will be necessary to use lower repeater gain or to change the location of the repeaters in order to reduce crosstalk. A location of excessive noise or crosstalk can be made by monitoring at the circuit terminal and terminating the line sections at different repeaters in turn, starting from the distant terminal until the crosstalk or noise disappears.

e. Poor Quality. Poor quality may occasionally be observed and will usually be caused by a bad tube, low battery voltage, or the

circuit being too close to the singing point. It may also be caused by an improper layout of the circuit which permits excessive transmission levels at the output of one or more repeaters, thus resulting in overloading. If the quality sounds hollow or tinny, this is an indication that the circuit may be close to the singing point and the trouble must be corrected either by reducing the gains used or by checking the balances at the different repeater points to locate any troubles which may exist. If the speech sounds mushy or has a quality generally associated with an overloaded radio set, the trouble is probably caused by overloading and the tubes, batteries, and output levels should be checked.

27. LAYOUT OF REPEATERED CIRCUITS.

a. General Considerations. The layout of a repeatered circuit is somewhat complicated since the gain in any one repeater and the distribution of gain in a multi-repeatered circuit are both subject to a number of limitations. Also, the correct setting of the equalizer switches must be determined. In this paragraph and paragraph 28, the general principles of laying out repeatered circuits, particularly with regard to the layout of repeater gains, are considered. Layouts are considered on the basis of standard Army net circuit equivalents of 6, 18, and 30 db; a 6-db circuit for built-up connections, an 18-db circuit for switchboard-to-switchboard with maximum local loop loss of 6 db on each end, and a 30-db circuit where no switching is involved. Table II and the simple rules which follow may be used to determine for any specific circuit the number of repeaters required and the approximate equalizer and gain settings for each repeater. In general, the setting for both equalizer switches and both gain switches for an individual repeater should be the same to simplify operation and maintenance.

b. Adjustment of Equalizers. The setting of the equalizer switches is important since the over-all transmission-frequency characteristic of the repeatered circuit should be as flat as possible to insure intelligible transmission. Also, excessive gain at any frequency should be avoided in order not to impair the repeater singing margins. Table I gives the setting of the equalizer switches. These are determined by the facility and to some extent by the length of circuit and the number of repeaters used. Ordinarily, the setting of both equalizers for an individual repeater should be the same. Where more than one type of facility is used in the make-up of a particular circuit, some judgment will be required to determine the proper equalizer setting. In general, where only one repeater is

used, the equalizer switches should be set for the lowest numbered position of the switch called for in the table for any of the component facilities. In a multi-repeatered circuit, divide the circuit into convenient parts so that each part contains one repeater, and determine the setting of the equalizer switches for each repeater as if its part of the circuit were a single repeatered circuit. If satisfactory over-all characteristics are not obtained, readjust the equalizer settings as required but not more than one step on each side of the repeater. If desired, after the circuit has been set up, over-all transmission-frequency measurements and talking tests may be made to determine what setting is optimum.

c. Repeater Gain. The 1,000-cycle gain of the repeater is the same for all settings of the equalizer and the markings on the gain-control switches correspond approximately to the gains which will be obtained at that frequency. In laying out a repeatered circuit, the 1,000-cycle gain will be used since allowable over-all standards for different types of circuits are set in terms of 1,000-cycle loss. The maximum gain of the repeater on equalizer switch positions 2 and 3 occurs at about 2,000 cycles and exceeds the 1,000-cycle gain. Therefore, it will be necessary to make certain that the network balances obtainable at 2,000 cycles are sufficient to maintain a satisfactory singing margin at that frequency when the gain settings have been determined upon the basis of the 1,000-cycle layout.

d. Circuit Net Loss. The net loss of a two-wire circuit is the total loss between circuit terminals and is equal to the sum of the losses minus the sum of the gains in one direction of transmission. It is usually expressed in terms of the 1,000-cycle gains and losses. The net loss should, of course, be the same for each direction of transmission and in order to avoid the possibility of singing around the over-all circuit when transmission variations occur, it is desirable to have the minimum net loss of the circuit at least 5 or 6 db. In many cases, the line loss and balance will be such that a net loss as low as this cannot be realized.

e. Repeater Output Level. The transmission level at any point in a circuit is equal to the sum of the gains minus the sum of the losses up to that point. The transmission level thus indicates the net gain or loss from the circuit terminal to the point in question. If the transmission level at the output of a repeater is too high, overloading will occur on loud talkers and the speech will sound mushy. The design of a two-wire repeater is such that the transmission level at the repeater output should not exceed +10 dbm; that is, 10-db net gain from the circuit terminals. The repeater

gains should be laid out so that this value of transmission level is not exceeded at any repeater when line losses are a minimum. In general, it is desirable to keep the repeater output levels reasonably high to over-ride line noises.

f. **Active Balance.** When speech is sent into a two-wire circuit, a certain amount of speech will be returned to the talker because the lines are not perfectly regular and because of imperfect balances between the lines and the networks at the repeaters. The paths by which these currents return are called echo paths. These paths may include a delay which makes the return currents sound like an echo of the original transmission. The active balance of the circuit is the number of decibels that the total of the returned currents is below the transmitted current. Active balance differs from ordinary repeater balance in that it is measured with all repeaters in the circuit at their normal gain, whereas repeater balance is measured with the line terminated at the far end of the repeater section under test. Hence, active balance may involve a number of echo paths while repeater balance involves only one echo path. If the active balance of a circuit is less than about 4 db, there will be excessive sidetone on echoes and the circuit will sound hollow. Transmission may also be impaired by echoes on connections which are built up by switching circuits in tandem.

g. **Singing Margin.** The singing margin is equal to the sum of the losses minus the sum of the gains around any possible singing path. that is, around any repeater. The gain layout should be such as to give a singing margin of at least 8 db under average conditions and 4 db under extreme conditions. If the singing margin is less than this, actual singing may not occur but distortion of the speech (near singing) will occur because of excessive circulating currents, particularly when the net loss varies toward the low side. If a circuit has only one repeater, the singing margin is simply the sum of the balances on the two sides of the repeater minus the sum of the gains in the two directions. In multi-repeatered circuits, there are several singing paths around a given repeater and the singing margin is approximately the sum of the active balances in the two directions minus the sum of the repeater gains in the two directions at the point being considered.

h. **Crosstalk.** Crosstalk conditions will be satisfactory if the loss from the input of one circuit to the receiving terminal of the other circuit is 60 db or better. Under extreme circumstances, as low as 43 db may be tolerable. In some cases, it may be necessary to limit the repeater gains in order to meet this requirement. The value of

the crosstalk coupling depends upon the type of exposure and the type of line. If a line having only one pair is used, there will be no crosstalk. With a line having two or more pairs, there will be pair-to-pair crosstalk. If phantom circuits are involved, phantom-to-side crosstalk in the same quad or group will usually be controlling.

28. RAPID CIRCUIT LAYOUT.

a. An approximate method for rapidly determining the specific layout of a repeatered circuit is given below. This method is based upon using a high repeater gain from the singing standpoint at any one repeater and does not consider echo, noise, and crosstalk. Consequently, it will not afford the optimum layout of the repeaters in every case and some readjustment may be required. The use of intermediate repeaters, only, is assumed and when applying this method, the minimum loss between any two repeaters should be at least 1.5 db greater than the gain of each repeater. After the circuit has been set up initially, over-all transmission measurements and talking tests should be made, if possible, to determine more accurately the optimum repeater settings. Such transmission measurements can be made readily, using Test Set I-61-C described in TM 11-346.

b. The approximate layout of repeatered circuits requires a knowledge of the 1,000-cycle losses of the more common wire facilities. This information is given in table II below. The attenuation values listed in this table represent approximate minimum losses. The transmission losses over open wire circuits may exceed these values by as much as 50 percent when the wires are wet. Similarly, the losses over cable pairs will increase 10 to 15 percent with a 75° F increase in temperature. The method described below will result in a circuit layout such that variations in weather and temperature will not seriously affect its operation.

c. To determine the layout for a specific circuit the length of the circuit is first compared with the maximum permissible operating distance as shown in table II to make sure the circuit is workable. The length of the circuit in miles is translated into db loss by use of table II. The total gain required is then computed for the desired circuit net loss. From this value, the number of repeaters and the gain for each repeater is determined and thus the correct GAIN switch settings are indicated. The minimum circuit net loss is finally checked to be sure that it will not be too low. The procedure for laying out a specific circuit is indicated in more detail as follows:

(*1*) Decide whether the circuit is to be laid out for 6, 18, or 30 db average circuit net loss.

(*2*) Check to make sure that the circuit is workable by comparing its length with the figures given in table II under the heading *Maximum miles of circuit* for the circuit net loss desired.

(*3*) Compute the *total attenuation* of the line as follows:

Total attenuation = length in miles × db loss per mile

(*4*) Using the following formula, compute the *total gain required:*

Total gain required = total attenuation − circuit net loss

(*5*) Determine the *number of repeaters required* as follows:

$$\text{Number of repeaters required} = \frac{\text{total gain required}}{14}$$

Since the number so computed usually comes out as a whole number with a fractional remainder, drop the fraction if it is less than ⅓ or increase the whole number by 1 and drop the fraction if the latter exceeds ⅓.

(*6*) Compute the *gain per repeater* as follows:

$$\text{Gain per repeater} = \frac{\text{total gain required}}{\text{number of repeaters}}$$

(*7*) Using the following formula, check the *minimum circuit net loss:*

Minimum circuit net loss = total attenuation of circuit − (number of repeaters × GAIN switch setting per repeater)

For a satisfactory layout, the answer should be greater than 1.5 multiplied by the number of repeaters, or greater than 6 db, whichever is the larger number. If this is not the case, the GAIN switch setting of one or more repeaters must be lowered by a total amount to satisfy this requirement.

TABLE II. RAPID CIRCUIT LAYOUT

Line facility	*Maximum miles of circuit† for circuit net loss* 6 db	18 db	30 db	*Average 1,000-cycle attenuation (db per mile)*
Open wire, copper				
0.104 nonloaded	420 (2)	1085 (4)	Any‡	0.067 (side) 0.052 (phantom)
0.128 nonloaded	490 (1)	1285 (4)	Any‡	0.047 (side) 0.038 (phantom)
0.165 nonloaded	530 (1)	1700 (4)	Any‡	0.030 (side) 0.025 (phantom)
Open wire, copper-steel, 40%				
0.080 nonloaded	225 (3)	400 (5)	Any‡	0.232 (side)
0.104 nonloaded	300 (3)	540 (5)	Any‡	0.152 (side) 0.127 (phantom)
Open wire, steel				
0.109 nonloaded	200 (3)	360 (5)	Any‡	0.290 (side)
Field wire				
W-143 nonloaded	30 (2)	72 (5)	Any‡	1.25
W-143, 3300-44	70 (1)	200 (3)		0.326
W-110-B nonloaded, wet	8 (1)	25 (3)		2.90
W-110-B nonloaded, damp	10 (1)	30 (3)		2.35
W-110-B nonloaded, dry	13 (1)	40 (3)		1.80
W-110-B, 5280-88, wet	18 (1)	54 (3)		1.32
W-110-B, 5280-88, damp	23 (1)	70 (3)		1.04
W-110-B, 5280-88, dry	30 (1)	95 (3)		0.76
W-110-B, 2 pairs on insulators spaced 12″ apart (metallic phantom)	40 (1)	180 (3)		0.397
Field cable				
WC-534 nonloaded	13 (1)	40 (3)		1.80
CC-358, 1320-6	33 (1)	100 (3)		0.71
Paper insulated cables				
19 ga, H-88-S	66 (1)	200 (3)		0.36
19 ga, H-50-P	80 (1)	240 (3)		0.30
19 ga, H-44-S	48 (1)	140 (3)		0.49
19 ga, H-25-P	60 (1)	180 (3)		0.40

† Figures in parentheses indicate number of repeaters.

‡ Minimum net loss must be at least 1.5 multiplied by number of repeaters or 6 db, whichever is larger. For 30-db circuits, any length likely to be used in practice will be satisfactory in regard to minimum net loss.

d. The layout procedure described above does not cover the use of the terminal repeaters. Terminal repeaters should be used wherever possible because of the reduction in manpower requirements and the availability of repeaters at terminals to allow occasional circuit adjustment. In general, only about half of the gain can be used at each terminal repeater as can be obtained from an intermediate repeater, hence in laying out a circuit to use terminal repeaters, two terminal repeaters may replace one intermediate repeater. In this case, the equalizer switch for the terminal transmitting amplifier will always be set on position 1, but both gain switches will be set at half the value used at intermediate repeaters.

e. The use of 22-type repeaters in twisted pair Wire W-110-B is not ordinarily worth while except for the case of one intermediate or two terminal repeaters. When this application is desirable to extend the range or improve the transmission of field wire, it is recommended that repeater sections be confined to not more than 7 miles in length and that moderate gains of about 4-8 db be used except in those cases where it is possible to expect 24-hour attendance for maintenance and readjustment. Networks are provided in the repeater which give very satisfactory balances against field wire under any weather conditions but the daily variations may require such frequent readjustment of the repeater that its use will generally require the compromise described above.

29. REPEATER BALANCE.

a. Knowledge of the balance between the line and network on either end of the repeater is useful for engineering purposes and as a check on the conditions of the line. It is measured as indicated in paragraph 21b. When actual measurements of the balance cannot be obtained, the following rules for estimating the approximate balance may be used for engineering repeatered circuit layouts.

b. If the line consists of open wire and is of moderately uniform construction with some entrance cable, but has little or no intermediate cables, few or no bridges, and no definite changes in gauge or spacing within a repeater section, it should be possible to obtain and maintain a balance of 25 db.

c. If the line consists of Wire W-143, nonloaded or loaded 44 millihenrys per 3,300 feet; or Cable WC-534, nonloaded; or Cable Assemblies CC-358 (loaded spiral-four cables); or any 16- or 19-gauge paper-insulated cable pairs or phantoms loaded H-44-25 or H-88-50, it should be possible to maintain a balance of 25 db.

d. If the line consists of open wire with changes of gauge or spacing and includes intermediate cable, a balance greater than 20 db should not be assumed for layout purposes and in some cases even lower balances may be experienced.

e. If the line is composed of Wire W-110-B, a balance of about 20 db should be obtained at any given time by proper network selection to correspond to the condition of moisture on the line wires. However, to attain any degree of freedom from the necessity of making continual readjustments of the networks, it is advisable to set the network for the weather conditions which will obtain for the greater part of the time. On such a compromise basis, only about a 12 db balance may be expected over an extended period of operation.

SECTION III

FUNCTIONING OF PARTS

30. THEORETICAL CONSIDERATIONS.

a. General. A telephone repeater is a device which, when connected into a telephone circuit, amplifies the volume of speech currents in order to overcome the transmission losses in the line wires. There are three fundamental types of repeaters now available for improving the transmission and extending the talking range of military communication facilities. These are:

(*1*) The four-wire repeater, providing separate amplifiers for transmission in opposite directions over separate pairs of wires. Telephone Repeater EE-99-A, described in TM 11-348, Telephone Repeater Set TC-29-A, is of this type.

(*2*) The 21-type repeater, providing simultaneous amplification in both directions over a single pair of wires but limited in application to lines of uniform characteristics throughout. Telephone Repeater EE-89-A, described in TM 11-2006, is a 21-type repeater.

(*3*) The 22-type repeater likewise provides simultaneous amplification in both directions over a single pair of wires but is capable of a wider use with various types of military wire facilities than the 21-type repeater. Telephone Repeater TP-14, described in this manual, is a 22-type repeater.

b. Theory of the 22-Type Repeater. The terminology 22-type implies a two-wire repeater having two amplifying elements. These elements are associated with the line wires in each direction through two hybrid coil arrangements. A hybrid coil constitutes a Wheatstone bridge circuit in which the impedance of the line wires is balanced against the impedance of a balancing network. The action of the hybrid coil is to detect the direction of flow of energy over the line and guide it properly through the amplifiers. The effectiveness of the hybrid coil depends upon how well the network is adjusted to balance the impedance of the line wires with which it is associated.

31. DESCRIPTION OF CIRCUIT FEATURES.

a. General. A complete schematic diagram of Telephone Repeater TP-14 is shown in figure 22. The principal transmission features may be seen more clearly in the block schematic shown in figure 9.

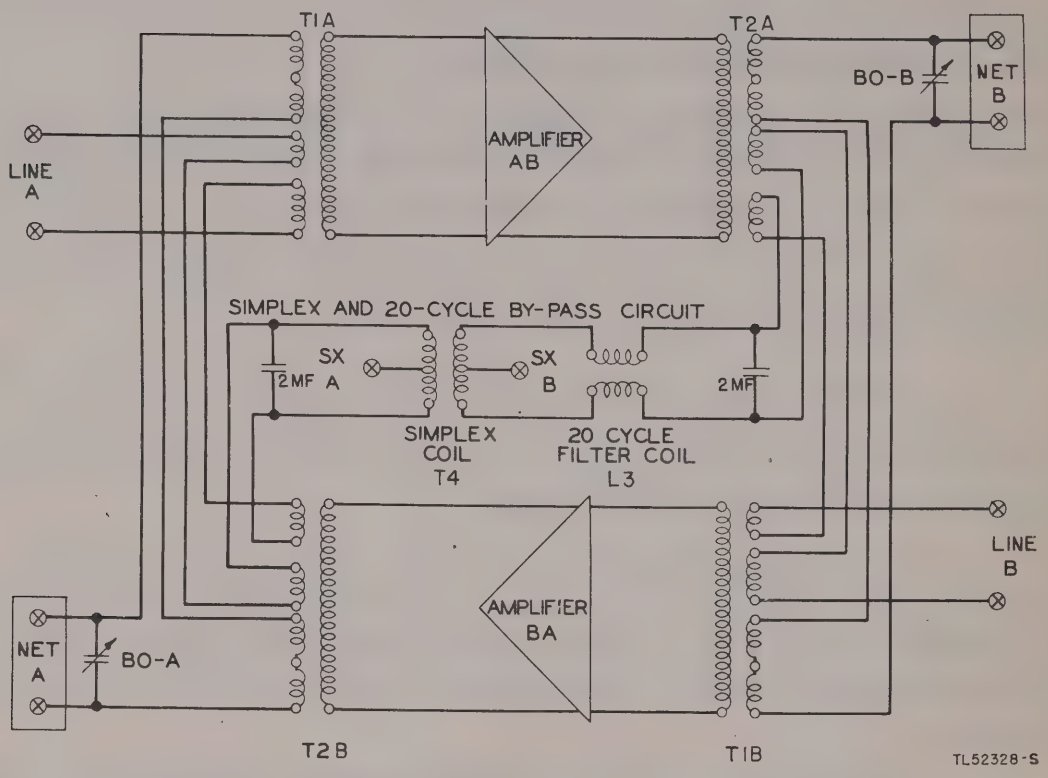


Figure 9. Telephone Repeater TP-14, block diagram.

b. Transmission Paths Through Repeater. The line wires in either direction are connected to the LINE A binding posts 4 and 5 and LINE B binding posts 12 and 13. These binding posts lead to windings on the transformers T1A and T1B, respectively, which in turn are connected to the windings of transformers T2B and T2A. Each pair of transformers is connected to form a hybrid arrangement for separating the two directions of transmission. Voice-frequency currents from direction A enter the repeater, are amplified in amplifier AB and are delivered to the line toward B. The resulting net amplification of current from line A to line B is termed the gain of the repeater and is expressed in db.

c. Hybrid Coil Arrangement. The two transformers forming a hybrid coil circuit function as follows:

(*1*) Energy from line A produces equal voltages in the line windings of both the T1A and T2B transformers, but, because of the reversed poling of the network windings of one coil with respect to those of the other coil, the resulting voltage across the network A is zero and the energy is equally divided between the input of amplifier AB and the output of amplifier BA. The latter half of the energy is wasted, becoming lost in the plate circuit of the receiving amplifier tube but the former half is amplified considerably and passed on to line B.

(*2*) In a similar manner, energy from line B, after passing through amplifier BA, induces equal voltages in the line and network windings of transformer T2B (assuming that line A and NET A impedances are equal). The resulting voltages in the corresponding windings of transformer T1A are also equal but, due to the reverse poling of the network windings, no voltage is induced in the winding connected to amplifier AB and the energy is equally divided between the outgoing line and the network.

d. Amplifiers. The voice-frequency currents which are impressed upon the amplifier pass through an equalizer-filter to the vacuum-tube amplifier. The equalizer-filter limits the transmission of frequencies above and below the useful voice range, thus preventing the repeater from singing at these frequencies. Three equalizer settings are provided. Step 1 affords the least slope in the characteristic and step 3, the greatest (the greatest difference between the gain at the high and low frequencies within the transmitted band). Step 2 is intermediate. In other respects, the vacuum-tube amplifier is of conventional design.

32. AMPLIFIERS AND EQUALIZERS.

a. General. Amplifiers AB and BA are identical and each is arranged to function from a variety of power sources through the power supply contained within the repeater. When the VOLTAGE SELECTOR switch is properly set for the type of power source connected to the repeater, operation of the POWER switch to the position ON connects the correct d-c voltages to the amplifier circuits.

b. Amplifier Circuit. Referring to figure 22, the complete amplifier circuit comprises an equalizer-filter, an input transformer, a gain-control potentiometer, a vacuum tube, and an output transformer, with supplementary resistors and capacitors to furnish grid bias, bypassing, and other similar functions.

(*1*) The equalizer-filter comprises an adjustable network consisting of resistors, capacitors, and inductances, arranged in three electrical groups under control of a five-pole, three-position rotary switch EQL-AB or EQL-BA. Position 1 of the EQL-AB or EQL-BA switch corresponds to a substantially flat gain-frequency characteristic; positions 2 and 3 give the degree of slope required for the line facilities listed in table I, paragraph 18e.

(*2*) The gain-control potentiometer consists of an eleven-position rotary switch including an off position X. Ten resistors of the correct values are connected in series with the switch contacts to form an over-all resistor, variable in 10 steps corresponding to 2 db each.

c. Power Supply Circuit. Power for operating the repeater is derived from the associated power equipment consisting of a power transformer, a 100-cycle vibrator, a selenium rectifier, a rectifier filter, and battery filter choke. The power equipment supplies the d-c voltages required for the plate and screen circuits of the vacuum tubes as well as the a-c voltage for the heaters of the tubes. The power source may be 110 to 130 or 220 to 250 volts, 50- to 60-cycle, a 12-volt storage battery, or a 135-volt and 12-volt dry batteries.

(*1*) *Operation from 110/220-volt, 50/60-cycle AC.* When the a-c mains are used, the VOLTAGE SELECTOR switch should be set at position 115 or 230 depending upon the voltage of the local supply. When the line cord is connected to the supply and the POWER switch turned to ON, power is connected to the primary of the power transformer T3. This voltage is transformed by the power transformer and is connected to the various elements in the repeater either directly, for those parts of the circuit requiring alternating current, or through a rectifier and filter for the required direct current. The L2 induction coil together with the C25 and C26 capacitors and R51 and R52 resistors constitute a filter which smooths out the ripple voltage in the output of the rectifier. An additional tap, terminated on terminal 11 of power transformer T3 is provided to compensate for lower than normal voltage supplies.

(*2*) *Operation from Storage or Dry Batteries.* The operation of the repeater power supply is essentially the same regardless of the power source. When an external 12-volt storage battery is used, however, the VOLTAGE SELECTOR switch should be set at position 12 and at position EXT when 12-volt and 135-volt dry bat-

teries are used. When operating from 12-volt storage battery, the vibrator is connected to a separate primary winding on the power transformer. Operation of the vibrator creates an interrupted d-c current which is similar in action to the a-c which would be provided by the 115- or 230-volt supply. The voltages thus available at the secondary side of the transformer are approximately the same as those obtained with a-c operation. The L1 induction coil and C23 capacitor form a filter to prevent the a-c component of the vibrator output from returning to the battery. When the VOLTAGE SELECTOR switch is in the EXT position, the power transformer and associated equipment are disconnected from the amplifiers and the external batteries are connected in their place.

33. BALANCING NETWORKS.

A network circuit and building-out capacitor are provided on each side of the repeater for balancing any of the line facilities listed in table I, paragraph 18e. The network circuit is composed of a number of resistors and capacitors which are arranged to be connected by means of two switches in such a way as to form the appropriate balancing network for the facility desired. The building-out capacitor is variable in eleven equal steps of 0.015 microfarad each, from zero to 0.15 microfarad, by means of a switch. Step 12 gives zero capacitance. The building-out capacitor is connected permanently across the network terminals of the hybrid coil. Its use is described in paragraph 18c.

34. BYPASS AND SIMPLEX-PHANTOM ARRANGEMENTS.

The circuit for bypassing 20-cycle ringing current around the repeater and for simplex telegraph is indicated in figure 9. The lines in either direction are connected together through the hybrid coils and a low-pass filter consisting of two capacitors C22A and C22B, a retardation coil L3, and a repeating coil T4. Voice-frequency currents will not traverse the bypass circuit because of its selective characteristics, but 20-cycle ringing currents are effectively transmitted from line A to line B. The repeating coil T4 breaks the d-c path and permits dropping a simplex circuit from either direction. The repeating coil T4 is balanced on both sides and electrostatically shielded to permit the simplex connections to be used as phantom legs in cases where two or three repeaters are used in a phantom group arrangement (figs. 4 and 5).

35. TRANSMISSION PERFORMANCE.

a. Gain. The gain of the repeater can be varied in steps of 2 db from 0 to 18. The markings on the GAIN-AB and GAIN-BA switches indicate the approximate 1,000-cycle gain. The gain at other frequencies in the voice range will vary from the 1,000-cycle gain depending upon the setting of the equalizer switches.

b. Load Carrying Capacity. The load carrying capacity of the amplifiers is sufficient to permit an output level at the line terminals of the repeater of +10 dbm, with negligible overloading. The total harmonic distortion with an output level of +15 dbm will not exceed 5 percent.

c. Gain-frequency Characteristics. Typical gain-frequency characteristics of the repeater at maximum gain setting for each of the three positions of the equalizer switches as measured in a 600-ohm resistive circuit are shown in figure 10. The shape of the characteristic is independent of gain switch setting. The actual gain of the repeater may depart, however, from these curves when the repeater is connected to circuits such as Wire W-143 (nonloaded) or loaded paper-insulated cables. The impedance mismatch between these facilities and the repeater causes this departure from the curves.

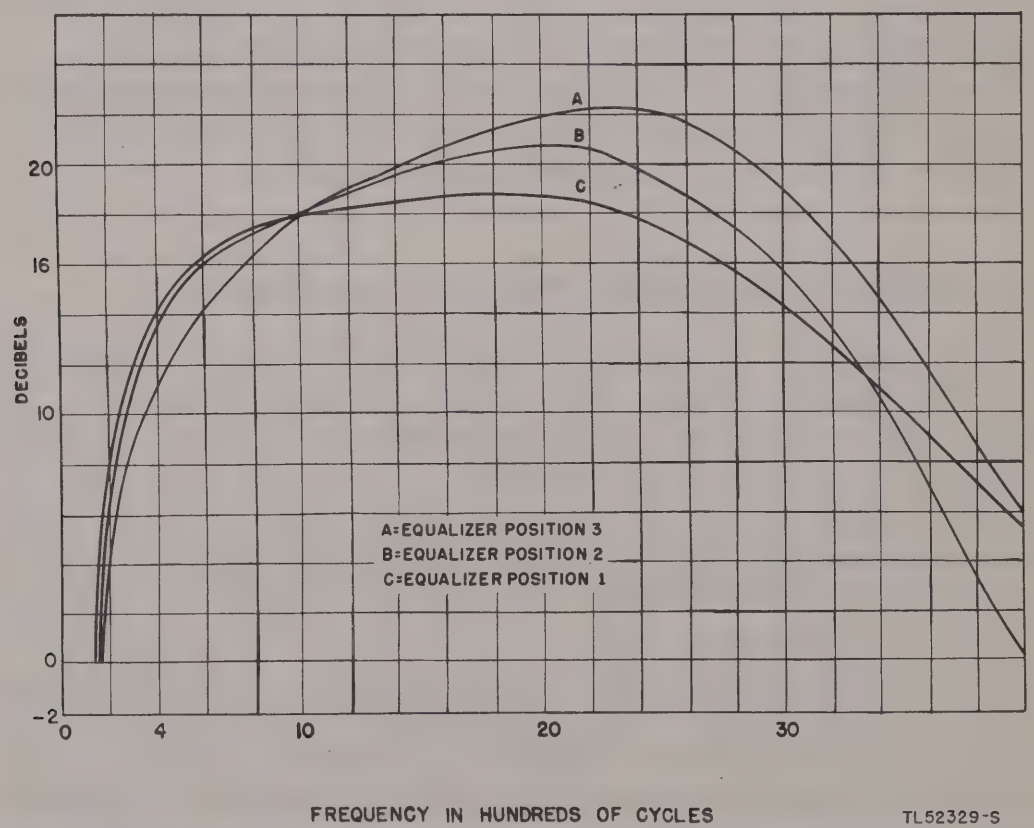


Figure 10. Telephone Repeater TP-14, gain-frequency characteristics.

d. Impedance. The nominal impedance looking into either the LINE A or LINE B terminals of the repeater is approximately 600 ohms over the useful voice-frequency range.

e. Aging of Batteries. When the repeater is operated from dry batteries, the gain and load carrying capacity will decrease and the impedance will increase as the batteries age. Tests have indicated that with fresh batteries and in temperate climate, these changes will not seriously affect the performance of the repeater under conditions of continuous use for a period up to about 3 weeks. While satisfactory performance may be obtained for somewhat longer periods, it is recommended that the batteries be changed periodically every 3 weeks, unless used under severe weather conditions in which case more frequent replacement may be required. For example, at an average temperature of 0° F, the batteries would have to be replaced every few days. If the batteries fail because of subjection to very low temperature, their life will return at normal temperature.

f. Loss to 20-cycle Ringing Circuits. The bypass circuit in a repeater introduces a small loss to 20-cycle ringing current which varies with circumstances. This loss may build up sufficiently in a long multi-repeatered circuit to prevent ringing between terminals. For such circuits, voice-frequency ringing must be used. Ringer TA-3/FT (TM 11-2011) or Ringing Equipment EE-101-A (Voice Frequency) (TM 11-342) may be utilized at each terminal for this purpose.

SECTION IV

MAINTENANCE

NOTE: Failure or unsatisfactory performance of equipment used by Army Ground Forces and Army Service Forces will be reported on W.D., A.G.O. Form No. 468 (Unsatisfactory Equipment Report): by Army Air Forces, on Army Air Forces Form No. 54 (unsatisfactory report). If either form is not available, prepare the data according to the sample form reproduced in figure 17.

36. SERVICING.

a. General. Be careful in handling the equipment during installation and operation to reduce the possibility of service failures. When replacing or adjusting apparatus on any of the units, do not disturb the wiring more than necessary. In soldering, be careful that no splashes of solder drop on apparatus parts of wiring terminals. Keep all parts, especially contact springs of switches, free from dirt and grease.

b. Inspection.

(*1*) Before placing Telephone Repeater TP-14 in service, and at regular intervals thereafter, inspect the equipment to insure proper working of parts.

(*2*) Check to see that the vacuum tubes and the vibrator are firmly seated in their sockets.

(*3*) Test vacuum tubes at least once a month and replace when necessary. Use Tube Tester I-177 or any other mutual conductance type tube tester. When inserting tubes into their sockets, be sure that the key on the base of the tube is aligned with a keyway of the tube socket.

(*4*) To locate trouble in the repeater chassis, disconnect the external line, switchboard, and power wires, and unfasten the eight screws holding the panel and chassis assembly to case. Lift the panel and chassis assembly out of the case by means of the two handles provided on the panel and remove the dust cover, thus

exposing the repeater parts to view. An airline wiring diagram is provided inside the dust cover.

(*5*) A circuit diagram and operating-instructions label is mounted inside the outer case cover.

(*6*) A trouble location and remedy chart is supplied in paragraph 40. Wiring diagram and interior views of the equipment to aid in trouble location are shown in figures 11, 12, 13, and 23.

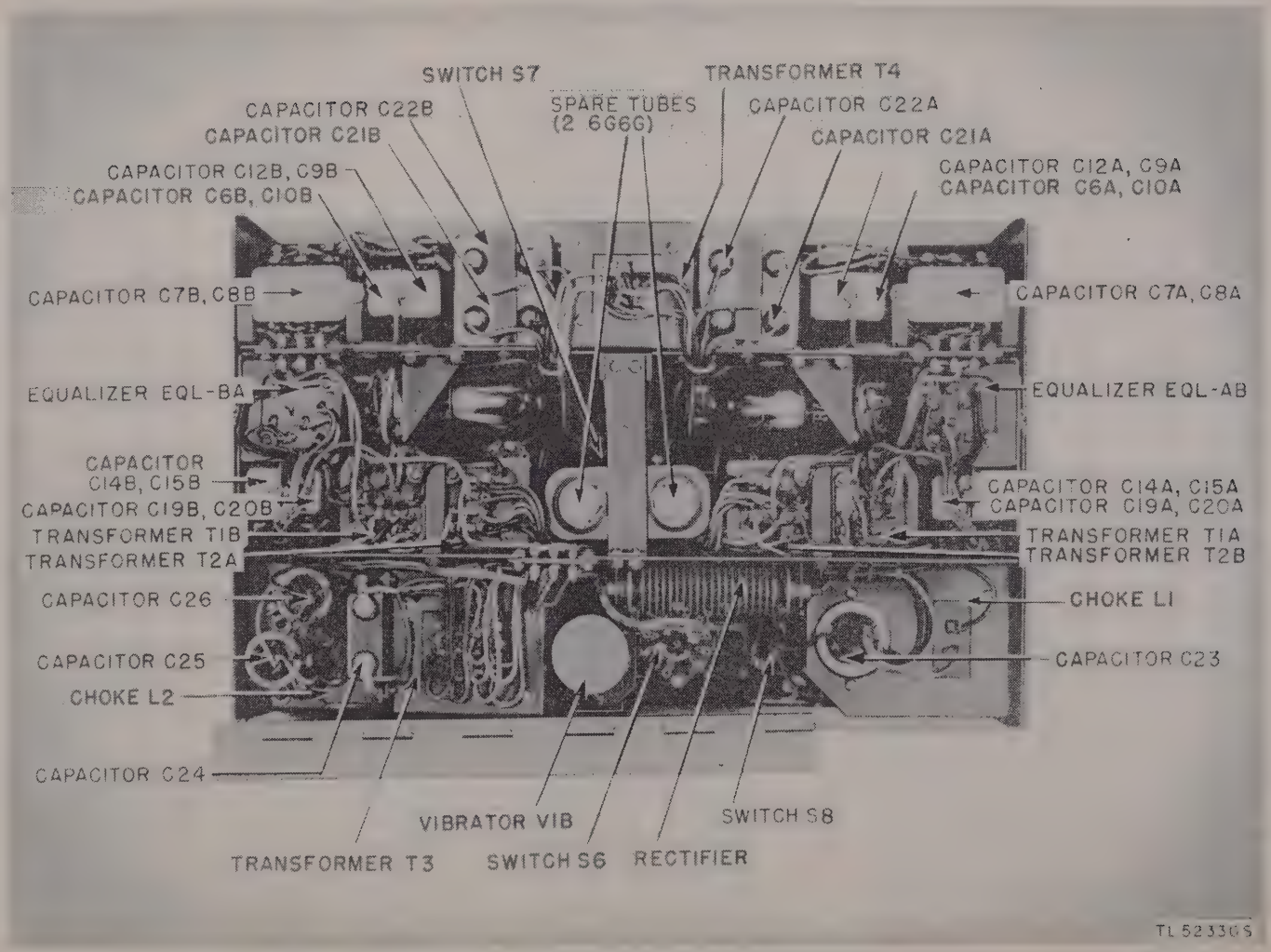


Figure 11. Telephone Repeater TP-14, dust cover removed, rear view.

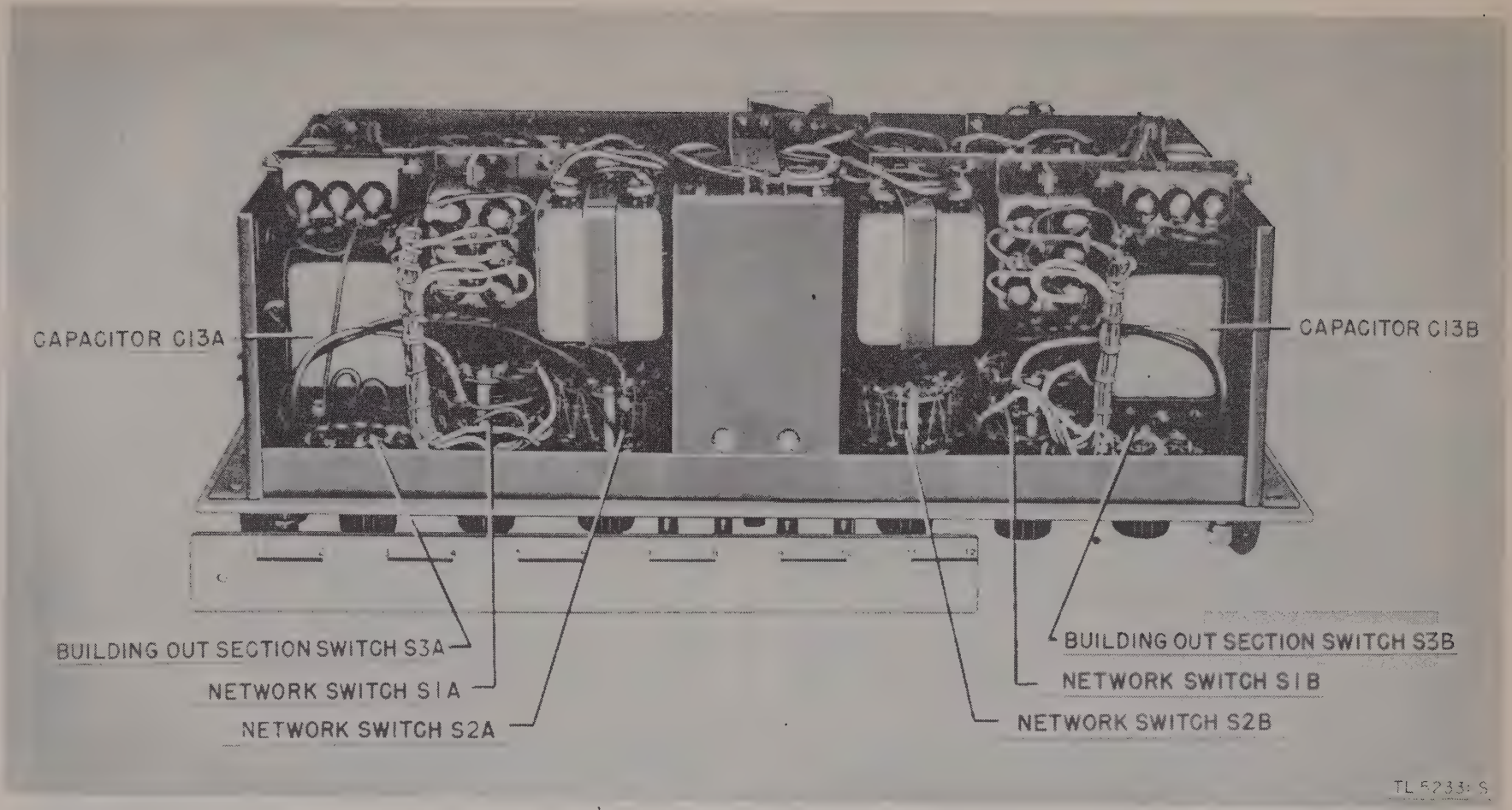


Figure 12. Telephone Repeater TP-14, dust cover removed, top view.

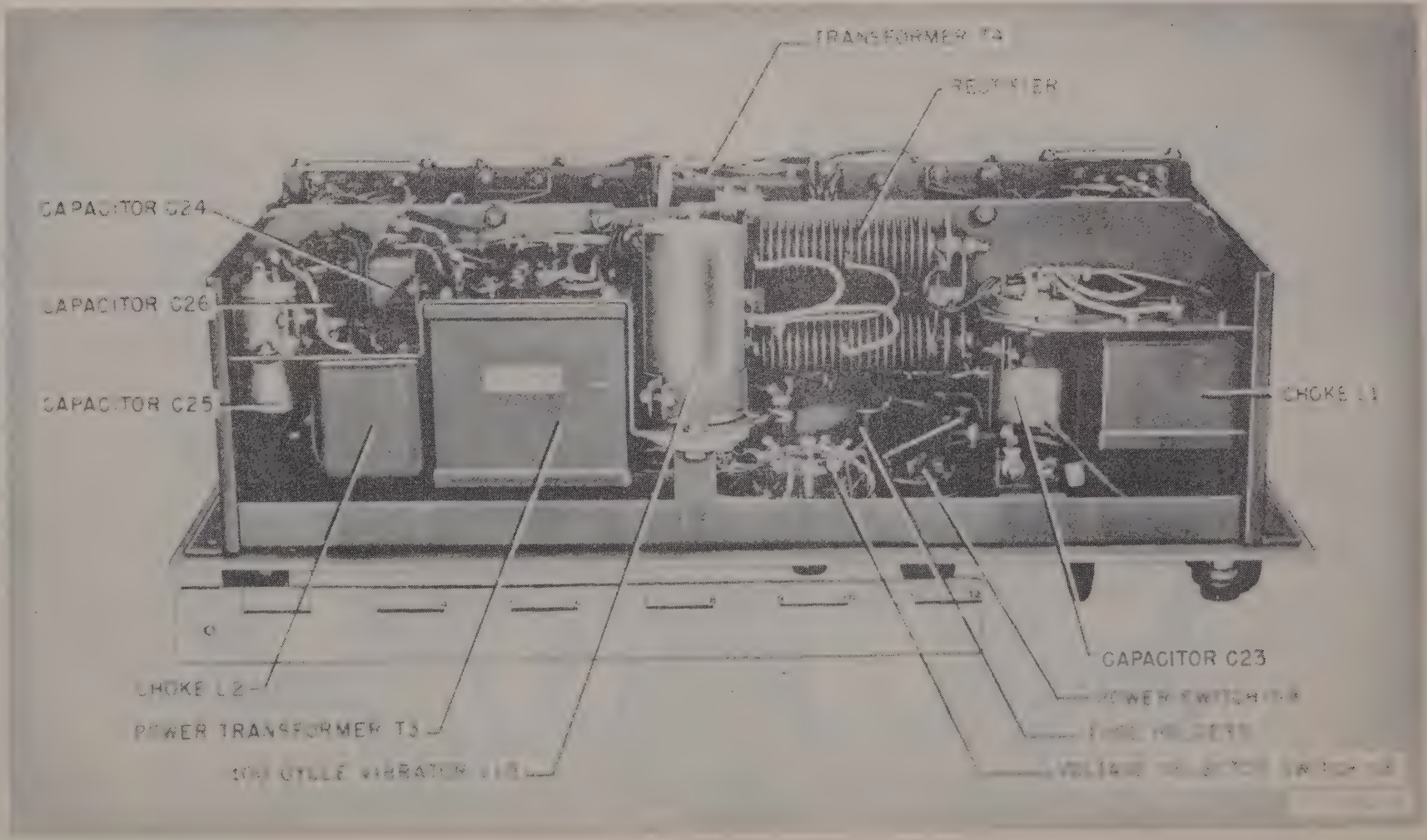


Figure 13. Telephone Repeater TP-14, dust cover removed, bottom view.

37. WIRING DIAGRAM.

a. The wiring diagram in this manual is of the airline type. It shows in semi-pictorial manner the actual physical arrangement of the equipment as viewed from the wiring side. Each piece of apparatus has the same marking as that stamped on the equipment, and the wiring terminals on each piece of apparatus are shown in their proper relative location as viewed from the wiring side. In addition, each piece of apparatus is assigned an arbitrary identification number. Feed lines, representing the individual wires between terminals of the apparatus are carried a short distance from the terminals and are terminated in a baseline which runs at right angles to the feed lines. These feed lines are marked with the color of the wire and have a number near the baseline which is the same as the identification number of the piece of apparatus to which the other end of the wire is connected. It is not necessary to trace a connection through the baseline; by noting the color and identification number of the feed line, it is possible to move directly to the other end of the wire. When a wire is shielded, color coding is impossible and in this case, each shielded wire is assigned an identification number. By using this number instead of the color code as is the case with other wires, it is possible to trace the wire as explained below.

b. To become familiar with the airline system, refer to the wiring diagram (fig. 23). To trace the wire from terminal 11 of T2A to pin 3 of V1-A, first locate T2A on the diagram. Note that the identification number assigned to this transformer is 58. The feed line between terminal 11 and the baseline is designated 60 OR-BR. This is an orange-brown wire terminating in a piece of apparatus designated 60. Next find the apparatus numbered 60. This is a socket for tube V1-A. A feed line designated 58 OR-BR extends from the baseline to pin 3 of the tube socket. This means that the orange-brown wire from terminal 11 on T2A is connected to pin 3 of the socket. Remember that it is not necessary to trace the connection through the baseline; move directly from one piece of apparatus to the other according to the identification numbers on the feed lines.

c. In general, wire colors shown on the wiring diagram are followed; occasionally other colors are substituted. For instance, solid colors such as green or blue may be replaced by corresponding colors with white tracers such as green-white and blue-white, respectively.

38. LUBRICATION.

Lubrication of Telephone Repeater TP-14 is not required.

39. MOISTUREPROOFING AND FUNGIPROOFING.

a. **General.** The operation of Signal Corps equipment in tropical areas where temperature and relative humidity are extremely high requires special attention. The following items represent problems which may be encountered in operation:

(*1*) Resistors, capacitors, coils, chokes, transformer windings, etc., fail.

(*2*) Electrolytic action takes place in resistors, coils, chokes, transformer windings, etc., causing eventual break-down.

(*3*) Hook-up wire and cable insulation break down. Fungus growth accelerates deterioration.

(*4*) Moisture forms electrical leakage paths on terminal boards and insulating strips, causing flash-overs and crosstalk.

(*5*) Moisture provides leakage paths between battery terminals.

b. **Treatment.** A moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection against fungus growth, insects, corrosion, salt spray, and moisture. The treatment involves the use of a moisture- and fungi-resistant varnish applied with a spray gun or brush. Refer to TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment, for a detailed description of the varnish-spray method of moistureproofing and fungiproofing and the supplies and equipment required in this treatment.

> **CAUTION:** Varnish spray may have toxic effects if inhaled. To avoid inhaling spray, use a respirator if available; otherwise, fasten cheesecloth or other cloth material over nose and mouth.

c. **Step-by-step Instructions for Treating Telephone Repeater TP-14.**

(*1*) *Preparation.* Make all repairs and adjustments necessary for proper operation of the equipment.

(2) *Disassembly.*

(*a*) Remove the eight large, roundhead, panel-retaining screws from the sides of the repeater panel.

(*b*) Lift the repeater chassis (to be treated) from its carrying case and remove the rear dust cover. (The case and dust cover are not to be treated.)

(*c*) Release the two pairs of large capacitors (C21A, C22A, C21B, and C22B) from their mountings. Do not disconnect the wiring. These capacitors are directly behind the NET A-2 and NET B-2 control switches.

(*d*) Unscrew and remove the vacuum tube spring clamping plate (not to be treated).

(*e*) Remove the two spare vacuum tubes.

(*f*) Release the V1-A and V1-B vacuum tube socket brackets from their mountings. Do not disconnect any wires.

(*g*) Turn the two BO and four NET control switches to steps 12 and EXT respectively and remove the knobs, mounting nuts, and washers.

(*h*) Release the A and B network subassemblies from their mountings by removing the two mounting screws in each main frame side plate. These screws are close to the dual capacitors C13/C11 which are immediately in back of the BO-A and BO-B control switches. Do not disconnect any wiring.

(*i*) Clean off all dirt, dust, rust, fungus, oil, grease, etc., from the equipment to be processed.

(3) *Masking.*

(*a*) *Power Supply.* Using cloth, cover the central rear section so that the selenium disk rectifier (RECT), POWER switch, and VOLTAGE SELECTOR switch are enclosed in one common protective cover (fig. 14(1)).

(*b*) *A and B Amplifier Assembly.*

1. Place strips of paper, about 2 inches wide by 5 inches long, between two small capacitor groups and their adjacent T1A and T1B transformers so that the paper extends down to the front panel (fig. 14(2) and (3)).

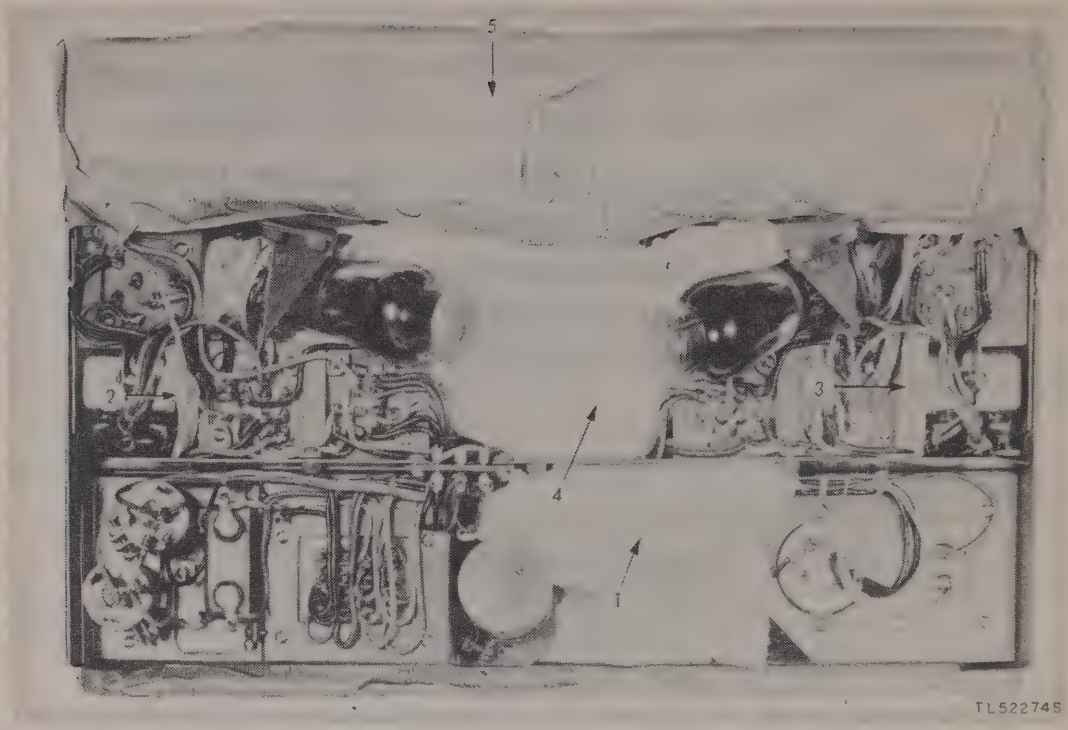


Figure 14. Telephone Repeater TP-14, masking of power supply, A and B amplifier assembly, and network assemblies.

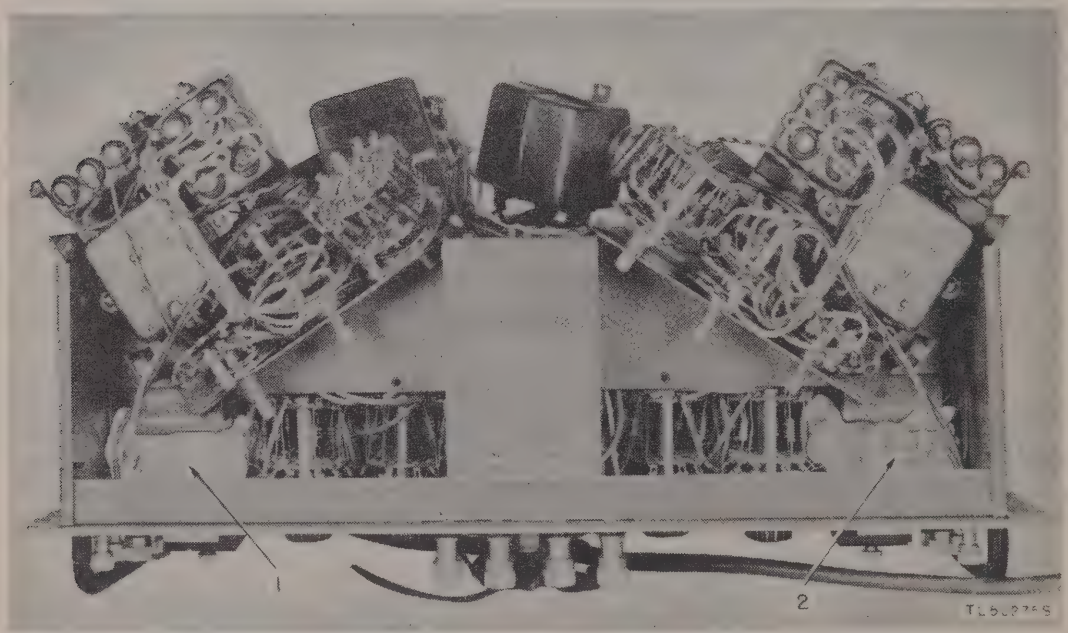


Figure 15. Telephone Repeater TP-14, masking of switches, EQL-AB and EQL-BA.

2. Move the two network assemblies back from the panel and tuck wads of cloth between switches EQL-AB and EQL-BA and their adjacent main frame side plates (fig. 15(1) and (2)).

3. Tuck in a piece of cloth over the backs of the five in-line switches and over the tops of the two spare vacuum tube sockets (fig. 14(4)). Close off all corners carefully.

(*c*) *Network Assemblies.* Replace the two network assemblies and the two pairs of capacitors (C21A, etc.) in their approximate normal positions. Cover this entire section with paper or cloth and seal the cover edges with masking tape (fig. 14(5)).

(*d*) *Front Panel.* Cover the front panel completely with paper or cloth and seal the cover edges with masking tape (fig. 16).

(*4*) *Drying.* Place the masked repeater in an oven or under heat lamps and dry for 4½ to 5½ hours at 135° F. *Do not exceed 135° F.*

(*5*) *Varnishing.* Apply three coats of moistureproofing and fungiproofing varnish (Lacquer, Fungus-resistant, spec No. 71-2202 (stock No. 6G1005.3), or equal) as follows:

CAUTION: Do not use lacquer which contains mercury upon this equipment.

(*a*) Spray all exposed connections, insulation, and small parts. Pay particular attention to the spraying of the small capacitor groups adjacent to transformers T1A and T1B.

(*b*) Upon completion of three spray coats, remove all masking.

(*c*) Brush all connections, wire ends, and small parts which were protected by the masking in the rear of the chassis. Do not allow the varnish to run onto the moving parts and contact surfaces of the switches. The EQL and GAIN switches of the amplifier assembly may be reached by moving the network assemblies.

(*d*) Brush the insulating washers of the 16 binding posts on the front panel. Loosen the line protector covers and carefully brush the edges of the insulating plate.

(*e*) Make a visual inspection of the chassis for coverage of all critical points and brush any portion where coverage is doubtful.

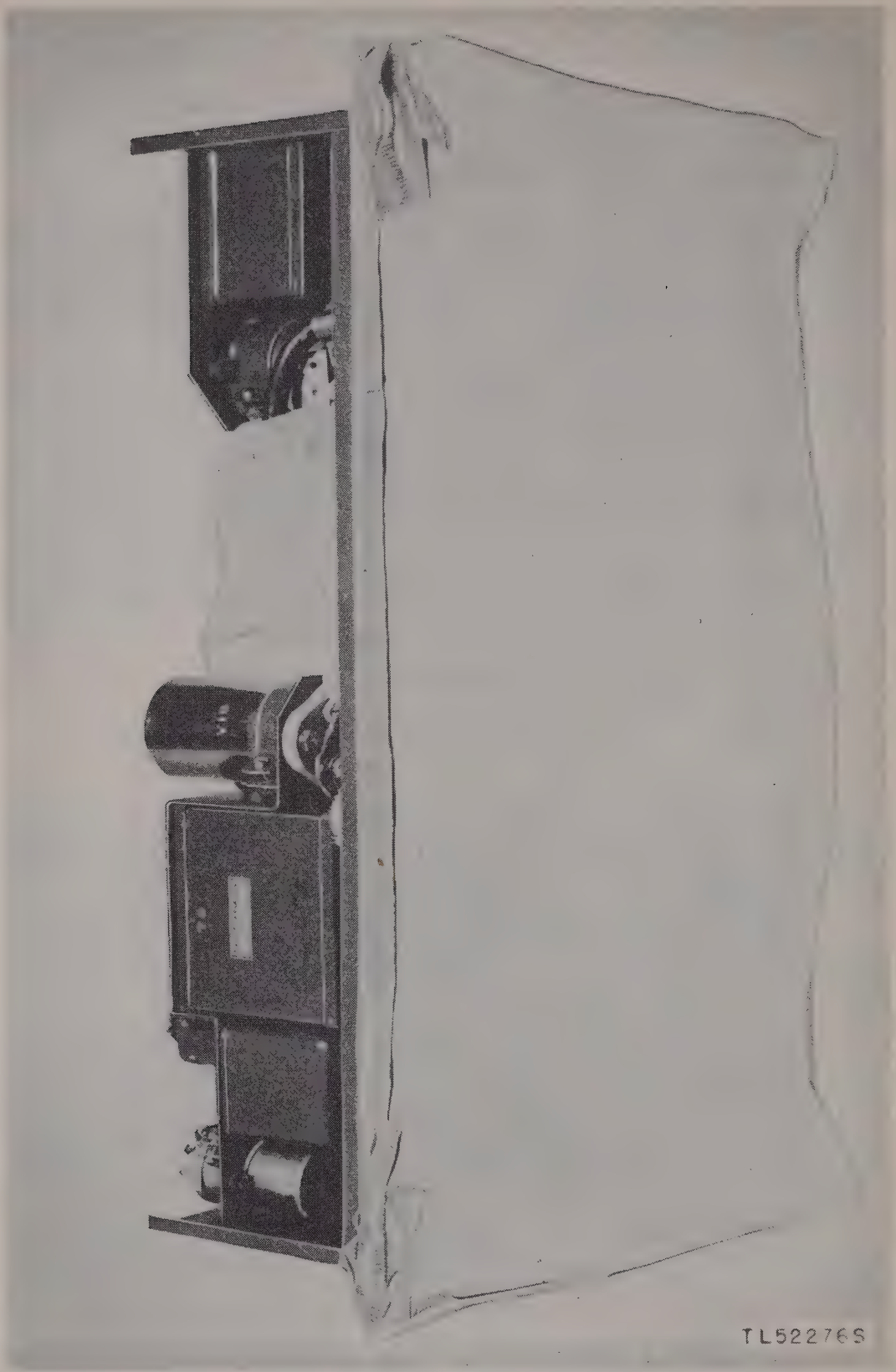


Figure 16. Telephone Repeater TP-14, masking of front panel.

(*6*) *Reassembly.*

(*a*) Reassemble the repeater and test its operation.

(*b*) If repairs are necessary, rebrush any disturbed portion of the varnish coat.

(*7*) *Marking.* Mark the letters MFP and the date of treatment near the nameplate on the equipment in such a location that the marking will not become obliterated or rubbed off.

EXAMPLE: MFP—12 Jan 45

40. TROUBLE LOCATION AND REMEDY CHART.

Indication	*Probable source of trouble*	*Suggested test*	*Remedy*
No speech signal comes through either channel.	Line A or Line B not connected or open.	Inspection.	Connect tested lines.
	Grounded or shorted line binding posts.	Check continuity from binding posts 4, 5, 12, and 13 to ground.	Inspect to determine cause. Replace broken binding post insulators.
		Check continuity across binding posts 4 and 5 and between binding posts 12 and 13. Compare resistance values obtained with those given in paragraph 42, point-to-point resistances.	Clean protector block holders of carbon or other accumulated dirt. Replace defective protector blocks.
	Open transformer windings.	Check continuity of windings 1-2 and 3-4 of transformers T1A and T2A and of transformers T1B and T2B. Check windings 1-4 and 5-8 of transformer T4.	Replace defective transformers.
	Open or shorted capacitors C22A and C22B.	Test capacitors C22A and C22B for open or short.	Replace if defective.

Tubes do not light.	Power cord not plugged in or batteries not connected.	Inspection.	Plug in cord or connect batteries as the case may be.
	POWER switch in OFF position.	Inspection.	Set POWER switch to ON.
	VOLTAGE SELECTOR switch incorrectly set.	Inspection.	Set VOLTAGE SELECTOR switch to correct position, corresponding to the supply used.
	Fuses blown.	Check fuse A.C. ½A. Check fuse BAT. 2A. Check fuse +135 1/16A.	Replace broken fuse.
	Defective tube (burned or broken filament of tube V1-A or V1-B).	Check tube with tube checker.	Replace defective tube.
	Break in filament circuit.	Check continuity of winding 9-10 of transformer T3 to ground.	Replace transformer T3 if winding is found to be open.

40. TROUBLE LOCATION AND REMEDY CHART (contd).

Indication	*Probable source of trouble*	*Suggested test*	*Remedy*
Tubes do not light (contd).	Break in filament circuit (contd).	Check circuit continuity: from terminal 2 on socket of tube V1-B to ground; from terminal 7 on socket of tube V1-A to 7 on socket of V1-B.	Replace broken wires.
		Check continuity from terminal 2 on socket of V1-A to terminal 8 on transformers T3 if the operating voltage is derived from a 110 vac source or from the vibrator. Check from terminal 2 on socket of V1-A to +12 binding post on the panel.	
No voltages at tube socket terminals.	Defective power supply.	Check voltage of batteries if external, 135-v batteries are used.	Replace batteries if voltage is considerably below rated value.

No voltages at tube socket terminals (contd).	Open or grounded filter choke L2.	Check continuity of terminals 1 and 2 of choke L2 to ground. A reading of zero indicates a grounded terminal. Disconnect the choke from the circuit and check continuity between terminals 1 and 2.	Replace choke if found to be defective.
	Shorted or open filter capacitors C24, C25, or C26.	Test capacitors for short, open, or ground using a high-range ohmmeter. The pointer should kick across scale and gradually return to a high value of resistance (at least 1 megohm). **NOTE: If the test is to be repeated the capacitor must first be discharged.**	Replace defective capacitors.
	Shorted or open windings of transformer T3.	Check continuity of transformer T3 windings for open or short.	Replace if defective.
	VOLTAGE SELECTOR switch points not making proper contact.	Check continuity between rotor and stator contacts on VOLTAGE SELECTOR switch.	Inspect and adjust loose contacts. If contact is broken or if adjustment cannot be made, replace switch.

40. TROUBLE LOCATION AND REMEDY CHART (contd).

Indication	*Probable source of trouble*	*Suggested test*	*Remedy*
No voltages at tube socket terminals (contd).	Grounded plate or screen grid terminals on sockets of tube V1-A or V1-B.	Check continuity from terminals 3 and 4 of sockets of tubes V1-A and V1-B to ground.	Inspect to determine cause of short-circuit. Replace socket if defective.
No speech signal comes through one channel.	Vacuum-tube improperly inserted.	Inspection.	Insert tube properly.
	Vacuum-tube prongs make improper contact with tube socket terminals.	Inspection.	Replace defective socket.
	Defective tube.	Test tube with tube checker for open or shorted elements and for proper emission.	Replace tube if defective.
	Open or grounded grid circuit.	Check continuity of terminal 5 of tube socket to ground. Inspect to determine cause of ground.	Replace socket if defective.

No speech signal comes through one channel (contd).	Open or grounded grid circuit (contd).	Check rotor of GAIN switch for proper contacts and for continuity to ground. Compare values thus obtained with those given in paragraph 42, point-to-point resistances.	Adjust switch contacts.
	Shorted windings 11-12 or 9-10 of transformer T1A or T1B.	Check d-c resistance of these windings.	Replace T1A or T1B if defective.
	EQL switch makes improper contact.	Check continuity of switch by measuring from points on the equalizer to terminal 8 of transformer T1A or T1B corresponding to the setting of switch EQL-AB or EQL-BA.	Adjust switch contacts. Replace if defective.
Speech signal fails to come through for some settings of GAIN switch.	Open resistor in GAIN switch.	Check resistance values between terminal 5 on tube socket and ground for various settings of GAIN switch. Compare with values given in paragraph 42, point-to-point resistances.	Replace defective resistor.

40. TROUBLE LOCATION AND REMEDY CHART (contd).

Indication	*Probable source of trouble*	*Suggested test*	*Remedy*
Singing.	Improper gain layout.	Reduce gain of the first repeater until singing just stops. Note the amount of the gain reduction and then restore the gain switches to normal.	Reduce the repeater gains enough to make singing point approximately equal on all repeaters.
		Repeat this procedure at each repeater in the circuit in turn.	
		If gain has to be reduced by the same amount at all repeaters to stop singing or if singing cannot be stopped by this procedure at any one repeater, the circuit has probably been laid out with too much gain, and singing is due to low net loss of the overall cricuit.	

Singing (contd).	Trouble in repeater	If the reduction in gain necessary to prevent singing is much larger at one repeater than at the other repeater in the circuit, the trouble is in the repeater.	Make balance test in each direction from the repeater in trouble. If the balance test on one side of the repeater is much lower than that on the other side, and is much lower than the values in the table, a trouble condition exists on that side of the repeater. Replace repeater and examine for loose or broken wires or for defective parts.
	Trouble in line.	If lines on the two sides of repeater are of same type, interchange the lines on the two ends of the repeater, that is, connect line on the A end to the B end and vice versa. If the abnormally low balance follows the line, the trouble is in the line. If the low balance remains on the same side of the repeater, the trouble is in the repeater.	If trouble is traced to line, the defect in the line must be traced and corrected.

40. TROUBLE LOCATION AND REMEDY CHART (contd).

Indication	*Probable source of trouble*	*Suggested test*	*Remedy*
Loss of volume.	Improper circuit layout.	Talk and monitor on circuit. To localize trouble monitor at each repeater in the circuit in turn. Note in which section the excessive volume loss seems to occur.	Try changing the tube associated with the direction of low gain.
	Wet line.		Increase gain of all repeaters on line by equal amounts.
	Defective line.	If net loss is excessive in both directions of transmission the trouble may be in either a repeater or in the line.	Check batteries and replace if run down. Check layout of line.
Crosstalk and noise.	One side of the repeater is grounded. One side of repeater is unbalanced to ground with respect to the other side. (a) Trouble on the line. (b) Dirty or grounded protector blocks.	Monitor at the circuit terminal, terminate the line sections at different repeaters in turn, starting from the distant terminal until the crosstalk or noise disappears.	Try using lower repeater gains. Try changing location of the repeaters.

Distorted speech signals.	(1) Bad tube. (2) Low battery voltage. (3) Circuit too close. (4) Improper layout of the circuit which permits excessive transmission levels at the output of one or more repeaters thus resulting in overloading.	(1) Check tubes using tube checker. (2) Check batteries. (3) Listen for hollow or tinny sounds. (4) Listen for husky or blurred speech.	(1) Replace defective tube. (2) Replace weak batteries. (3) Reduce gains used. (4) Check the balance at the different repeater points.

WAR DEPARTMENT

UNSATISFACTORY EQUIPMENT REPORT

FOR (Technical service) Signal Corps — MATERIEL — DATE: 26 Feb 45

FROM (Organization) 568 Sig Repair Co. — (Station) APO 215

TO (Next superior headquarters) — (Station) San Francisco (Technical service)

COMPLETE MAJOR ITEM

NOMENCLATURE: Telephone Repeater TP-14 — TYPE: 22-Type

MODEL — MANUFACTURER: Federal Telephone and Radio Corp.

U. S. A. REG. NO.: Order No. 27860-Phila-44 — SERIAL NO.: 42 — DATE RECEIVED: 15 Jan 45

EQUIPMENT WITH WHICH USED (IF APPLICABLE)

NOMENCLATURE OF DEFECTIVE COMPONENT

PART NO.: Sig C stock No. 27-9613.359 — TYPE: Transformer, power

MANUFACTURER: Federal Telephone and Radio Corp. — DATE INSTALLED: 18 Jan 45

LENGTH OF SERVICE

DATE OF INITIAL TROUBLE: 6 Feb 45

TOTAL TIME INSTALLED: YEARS — MONTHS: 1 — DAYS: 8

TOTAL PERIOD OF OPERATION BEFORE FAILURE (FILL IN WHERE APPLICABLE)

YEARS	MONTHS	DAYS	HOURS	MILES	ROUNDS
		12			

DESCRIPTION OF TROUBLE AND PROBABLE CAUSE

GIVE TYPE OF FAILURE, MECHANICAL, ELECTRICAL, WORKMANSHIP, MATERIAL, DESIGN

Transformer winding breaks down due to operation in humid climate

UNUSUAL SERVICE CONDITIONS

GIVE BRIEF DESCRIPTION

Operation in tropics

TRAINING OR SKILL OF USING PERSONNEL (CHECK ONE) — POOR — FAIR — GOOD ✓

DESCRIPTION OF ANY REMEDIAL ACTION TAKEN

Moistureproofing treatment applied 8 Feb 45

RECOMMENDATIONS

Redesign of transformer for operation in Tropics

1ST IND

OFFICE — STATION — DATE

TO CHIEF (Technical service) Signal Officer, Washington 25, D.C.

NAME — STATION — RANK

ORIGINATING OFFICER

SIGNATURE: John J. Jones

NAME: JOHN J. JONES

RANK AND TITLE: Capt., Sig C

ORGANIZATION: 568 Sig Repair Co.

INSTRUCTIONS

1. It is imperative that the Chief of Technical Service concerned be advised at the earliest practical moment of any constructional, design, or operational defect in matériel. This form is designed to facilitate such reports and to provide a uniform method of submitting the required data.

2. This form will be used for reporting manufacturing, design or operational defects in matériel with a view to improving and correcting such defects, and for use in recommending modifications of matériel.

3. This form will not be used for reporting failures, isolated material defects or malfunctions of matériel resulting from fair-wear-and-tear or accidental damage nor for the replacement, repair, or the issue of parts and equipment. It does not replace currently authorized operational or performance records.

4. Reports of malfunctions and accidents involving ammunition will continue to be submitted as directed in the manner described in AR 750-10 (Change No. 3).

5. It will not be practicable or desirable in all cases to fill all blank spaces of the report. However, the report should be as complete as possible in order to expedite necessary corrective action. Additional pertinent information not provided for in the blank spaces should be submitted as inclosures to the form. Photographs, sketches or other illustrative material are highly desirable.

6. When cases arise where it is necessary to communicate with a chief of service in order to assure safety to personnel, more expeditious means of communication are authorized. This form should be used to confirm reports made by more expeditious means.

7. This form will be made out by using or service organizations and forwarded in duplicate through command channels to the chief of technical service. The office of the chief of technical service receiving the report will forward an information copy to the Commanding General, Army Ground Forces or Army Air Forces, whichever is applicable, and to the Commanding General, Army Service Forces.

8. Necessity for using this form will be determined by the using or service troops.

W. D., A. G. O. Form No. 468
1 December 1943

16—37786-1 U. S. GOVERNMENT PRINTING OFFICE
TL52318-S

Figure 17. W.D., A.G.O. Form No. 468 with sample entries.

41. UNSATISFACTORY EQUIPMENT REPORT.

a. When trouble in equipment used by the Army Ground Forces or Army Service Forces occurs more often than repair personnel feel is normal, War Department Unisatisfactory Equipment Report, W.D., A.G.O. Form No. 468 (fig. 17), should be filled out and forwarded through channels to the Office of the Chief Signal Officer, Washington 25, D. C.

b. When trouble in equipment used by the Army Air Forces occurs more often than repair personnel feel is normal, Army Air Forces Form No. 54 should be filled out and forwarded through channels.

c. If either form is not available, Form No. 468 (fig. 17) may be reproduced, filled out, and forwarded through channels. When Army Air Forces Form No. 54 is required but not available, reproduce Form No. 468 and forward it through channels in accordance with directions on Form No. 468.

42. POINT-TO-POINT RESISTANCE VALUES.

From terminal	On	To terminal	On	SW	Pos	Approx Ohms	Remarks
1	T1A	2	T1A			11	Remove all wires from binding posts #4 and #5.
3	T1A	4	T1A			11	See above.
1	T2B	2	T2B			17.5	See above.
3	T2B	4	T2B			17.5	See above.
1	T4	2	T4			35	See above.
3	T4	4	T4			35	See above.
4-5 SX	Panel	4	T4			35	See above.
4-5 SX	Panel	1	T4			35	See above.
5	T1A	6	T1A	S2A, S3A	EXT 12	22	Remove all wires from binding posts #6 and #7.
5	T2B	6	T2B	S2A, S3A, S1A	EXT 12	35	See above.
1	T2A	2	T2A			17.5	Remove all wires from binding posts #12 and #13.
3	T2A	4	T2A			17.5	See above.
1	T1B	2	T1B			11	See above.
3	T1B	4	T1B			11	See above.
5	T4	6	T4			42	See above.
7	T4	8	T4			42	See above.
1	L3	2	L3			68	See above.
3	L3	4	L3			68	See above.
12-13 SX	Panel	2	L3			110	See above.
12-13 SX	Panel	3	L3			110	See above.
7	T2A	8	T2A	S7	MON	11	Remove all wires from binding posts #8 and #9.
8	T2A	9	T2A	S7	MON	34	See above.
7	T2B	8	T2B	S7	MON	11	See above.
8	T2B	9	T2B			34	See above.
5	T2A	6	T2A	S2B, S3B, S1B	EXT 12	35	Remove all wires from binding posts #10 and #11.
5	T1B	6	T1B	S2B, S3B, S1B	EXT 12	22	See above.
7	T1A	8	T1A			32	Remove all wires from terminals #7 and #9 on T1A.

42. POINT-TO-POINT RESISTANCE VALUES (contd).

From terminal	On	To terminal	On	SW	Pos	Approx Ohms	Remarks
8	T1A	GND		EQL-AB	1	730	See above.
8	T1A	GND		EQL-AB	2	488	See above.
8	T1A	GND		EQL-AB	3	405	See above.
9	T1A	10	T1A			48	See above.
10	T1A	GND		EQL-AB	1	433	See above.
10	T1A	GND		EQL-AB	2	272	See above.
10	T1A	GND		EQL-AB	3	73	See above.
11	T1A	12	T1A			3,150	Remove all wires from terminal #11 and T1A.
5	V1-A	GND		GAIN-AB	X	11	See above.
5	V1-A	GND		GAIN-AB	0	33,000	See above.
5	V1-A	GND		GAIN-AB	2	41,200	See above.
5	V1-A	GND		GAIN-AB	4	51,200	See above.
5	V1-A	GND		GAIN-AB	6	64,200	See above.
5	V1-A	GND		GAIN-AB	8	80,200	See above.
5	V1-A	GND		GAIN-AB	10	100,200	See above.
5	V1-A	GND		GAIN-AB	12	127,200	See above.
5	V1-A	GND		GAIN-AB	14	160,200	See above.
5	V1-A	GND		GAIN-AB	16	203,200	See above.
5	V1-A	GND		GAIN-AB	18	254,200	See above.
7	T1B	8	T1B			32	Remove all wires from terminal #7 and #9 on T1B.
8	T1B	GND		EQL-BA	1	730	See above.
8	T1B	GND		EQL-BA	2	488	See above.
8	T1B	GND		EQL-BA	3	405	See above.
9	T1B	10	T1B			48	See above.
10	T1B	GND		EQL-BA	1	433	See above.
10	T1B	GND		EQL-BA	2	272	See above.
10	T1B	GND		EQL-BA	3	73	See above.
10	T2A	11	T2A			700	
10	T2B	11	T2B			700	
11	T1B	12	T1B			3,150	Remove all wires from terminal #11 on T1B.
5	V1-B	GND		GAIN-BA	X	11	See above.
5	V1-B	GND		GAIN-BA	0	33,000	See above.
5	V1-B	GND		GAIN-BA	2	41,200	See above.
5	V1-B	GND		GAIN-BA	4	51,200	See above.
5	V1-B	GND		GAIN-BA	6	64,200	See above.
5	V1-B	GND		GAIN-BA	8	80,200	See above.
5	V1-B	GND		GAIN-BA	10	100,200	See above.
5	V1-B	GND		GAIN-BA	12	127,200	See above.

42. POINT-TO-POINT RESISTANCE VALUES (contd).

From terminal	On	To terminal	On	SW	Pos	Approx Ohms	Remarks
5	V1-B	GND		GAIN-BA	14	160,200	See above.
5	V1-B	GND		GAIN-BA	16	203,200	See above.
5	V1-B	GND		GAIN-BA	18	254,200	See above.
8	V1-A	GND				750	
4	V1-A	GND		S6	12	41,000	
4	V1-A	GND		S6	115	41,000	
2	V1-A	GND				0	
3	V1-A	4	V1-A			700	
7	V1-A	7	V1-B			0	
8	V1-B	GND				750	
4	V1-B	GND		S6	12	41,000	
4	V1-B	GND		S6	115	41,000	
2	V1-B	GND		S6	115	0	
3	V1-B	4	V1-B			700	
1	T3	2	T3			75	
2	T3	3	T3			250	
4	T3	5	T3			1.2	Remove vibrator from socket.
5	T3	6	T3			1.2	See above.
7	T3	8	T3	S6	EXT	3.5	
9	T3	10	T3			220	Remove all wires from terminal #9 on T3.
10	T3	11	T3			30	See above.
1	L1	2	L1			1.8	
1	L2	2	L2			120	Remove all wires from terminal #1 on L2.
1	L2	GND				41,000	
2	L2	GND				41,000	
4	Panel	5	Panel			127	
6	Panel	7	Panel	S1A, S2A	EXT, EXT	57	
8	Panel	9	Panel	S7	MON	10,000	
8	Panel	9	Panel	S7	Talk Line A	45	
8	Panel	9	Panel	S7	Talk Line B	45	
10	Panel	11	Panel	S1B, S2B	EXT, EXT	250	
12	Panel	13	Panel			270	
6	T1B	5	T2A	S2B, S1B	1, 1	2,265	Disconnect wire from terminal #6 on T2A.
6	T1B	5	T2A	S2B, S1B	1, 2	2,265	See above.
6	T1B	5	T2A	S2B, S1B	1, 3	2,265	See above.

42. POINT-TO-POINT RESISTANCE VALUES (contd).

From terminal	On	To terminal	On	SW	Pos	Approx Ohms	Remarks
6	T1B	5	T2A	S2B, S1B	1, 4	2,265	See above.
6	T1B	5	T2A	S2B, S1B	1, 5	2,565	See above.
6	T1B	5	T2A	S2B, S1B	1, 6	2,465	See above.
6	T1B	5	T2A	S2B, S1B	1, 7	2,705	See above.
6	T1B	5	T2A	S2B, S1B	1, 8	4,235	See above.
6	T1B	5	T2A	S2B, S1B	1, 9	3,325	See above.
6	T1B	5	T2A	S2B, S1B	1, 10	00	See above.
6	T1B	5	T2A	S2B, S1B	1, 11	65	See above.
6	T1B	5	T2A	S2B, S1B	1, EXT	65	See above.
6	T1B	5	T2A	S1B, S2B	11, 2	75	See above.
6	T1B	5	T2A	S1B, S2B	11, 3	85	See above.
6	T1B	5	T2A	S1B, S2B	11, 4	100	See above.
6	T1B	5	T2A	S1B, S2B	11, 5	130	See above.
6	T1B	5	T2A	S1B, S2B	11, 6	160	See above.
6	T1B	5	T2A	S1B, S2B	11, 7	380	See above.
6	T1B	5	T2A	S1B, S2B	11, 8	390	See above.
6	T1B	5	T2A	S1B, S2B	11, 9	400	See above.
6	T1B	5	T2A	S1B, S2B	11, 10	410	See above.
6	T1B	5	T2A	S1B, S2B	11, 11	420	See above.
6	T1B	5	T2A	S1B, S2B	11, 12	450	See above.
6	T1B	5	T2A	S1B, S2B	11, 13	501	See above.
6	T1B	5	T2A	S1B, S2B	11, 14	552	See above.
6	T1B	5	T2A	S1B, S2B	11, 15	603	See above.
6	T1B	5	T2A	S1B, S2B	11, 16	654	See above.
6	T1B	5	T2A	S1B, S2B	11, 17	705	See above.
6	T1B	5	T2A	S1B, S2B	11, 18	756	See above.
6	T1B	5	T2A	S1B, S2B	11, 19	807	See above.
6	T1B	5	T2A	S1B, S2B	11, 20	902	See above.
6	T1B	5	T2A	S1B, S2B	11, 21	1,007	See above.
6	T1B	5	T2A	S1B, S2B	11, 22	1,107	See above.
6	T1B	5	T2A	S1B, S2B	11, 23	1,207	See above.
6	T1B	5	T2A	S1B, S2B	11,EXT	00	See above.
6	T1A	5	T2B	S2A, S1A	1, 1	2,265	Disconnect wire from terminal # 6 on T2B.
6	T1A	5	T2B	S2A, S1A	1, 2	2,265	See above.
6	T1A	5	T2B	S2A, S1A	1, 3	2,265	See above.
6	T1A	5	T2B	S2A, S1A	1, 4	2,265	See above.
6	T1A	5	T2B	S2A, S1A	1, 5	2,565	See above.
6	T1A	5	T2B	S2A, S1A	1, 6	2,465	See above.
6	T1A	5	T2B	S2A, S1A	1, 7	2,705	See above.
6	T1A	5	T2B	S2A, S1A	1, 8	4,235	See above.
6	T1A	5	T2B	S2A, S1A	1, 9	3,325	See above.
6	T1A	5	T2B	S2A, S1A	1, 10	00	See above.

42. POINT-TO-POINT RESISTANCE VALUES (contd).

From terminal	On	To terminal	On	SW	Pos	Approx Ohms	Remarks
6	T1A	5	T2B	S2A, S1A	1, 11	65	See above.
6	T1A	5	T2B	S2A, S1A	1, EXT	65	See above.
6	T1A	5	T2B	S1A, S2A	11, 2	75	See above.
6	T1A	5	T2B	S1A, S2A	11, 3	85	See above.
6	T1A	5	T2B	S1A, S2A	11, 4	100	See above.
6	T1A	5	T2B	S1A, S2A	11, 5	130	See above.
6	T1A	5	T2B	S1A, S2A	11, 6	160	See above.
6	T1A	5	T2B	S1A, S2A	11, 7	380	See above.
6	T1A	5	T2B	S1A, S2A	11, 8	390	See above.
6	T1A	5	T2B	S1A, S2A	11, 9	400	See above.
6	T1A	5	T2B	S1A, S2A	11, 10	410	See above.
6	T1A	5	T2B	S1A, S2A	11, 11	420	See above.
6	T1A	5	T2B	S1A, S2A	11. 12	450	See above.
6	T1A	5	T2B	S1A, S2A	11, 13	501	See above.
6	T1A	5	T2B	S1A, S2A	11, 14	552	See above.
6	T1A	5	T2B	S1A, S2A	11, 15	603	See above.
6	T1A	5	T2B	S1A, S2A	11, 16	654	See above.
6	T1A	5	T2B	S1A, S2A	11, 17	705	See above.
6	T1A	5	T2B	S1A, S2A	11, 18	756	See above.
6	T1A	5	T2B	S1A, S2A	11, 19	807	See above.
6	T1A	5	T2B	S1A, S2A	11, 20	907	See above.
6	T1A	5	T2B	S1A, S2A	11, 21	1,007	See above.
6	T1A	5	T2B	S1A, S2A	11, 22	1,107	See above.
6	T1A	5	T2B	S1A, S2A	11, 23	1,207	See above.
6	T1A	5	T2B	S1A, S2A	11,EXT	00	See above.
1	L4A	2	L4A			4.7	Disconnect wire from Term 1 on L4A.
3	L4A	4	L4A			2.85	See above.
1	L4B	2	L4B			4.7	Disconnect wire from Term #1 on L4B.
3	L4B	4	L4B			2.85	See above.

43. POINT-TO-POINT VOLTAGES, 115-VOLT A-C SUPPLY.

From terminal	Part No.	To terminal	Part No.	SW No.	Pos	Remarks	Approx Voltage
7	T3	8	T3	S6	115	115 v ac between 1 + 2 on T3	13 v AC
9	T3	10	T3	Do.	Do.	Do.	135 v AC
9	T3	11	T3	Do.	Do.	Do.	145 v AC
1	L2	GND		Do.	Do.	Do.	147 v DC
2	L2	GND		Do.	Do.	Do.	133 v DC
2	V1-A	7	V1-A	Do.	Do.	Do.	6.5 v AC
2	V1-B	7	V1-B	Do.	Do.	Do.	6.5 v AC
3	V1-A	GND		Do.	Do.	Do.	179 v DC
4	V1-A	GND		Do.	Do.	Do.	133 v DC
5	V1-A	GND		Do.	Do.	Do.	0
8	V1-A	GND		Do.	Do.	Do.	7.3 v DC
3	V1-B	GND		Do.	Do.	Do.	129 v DC
4	V1-B	GND		Do.	Do.	Do.	133 v DC
5	V1-B	GND		Do.	Do.	Do.	0
8	V1-B	GND		Do.	Do.		7.3 v DC

44. VACUUM-TUBE CHARACTERISTICS.

Vacuum Tube 6G6-G (VT-198-A) is a power-amplifier pentode of the heater cathode type, housed in a glass bulb. Its small-shell, seven-pin base fits the standard octal socket. It may be used as an oscillator, detector, or amplifier.

Characteristic	
Heater voltage (ac or dc)	6.3 volts
Heater current	0.15 ampere
Grid-to-plate capacitance	0.50 mmf
Input capacitance	5.5 mmf
Output capacitance	7.0 mmf

Maximum operating conditions as an amplifier:

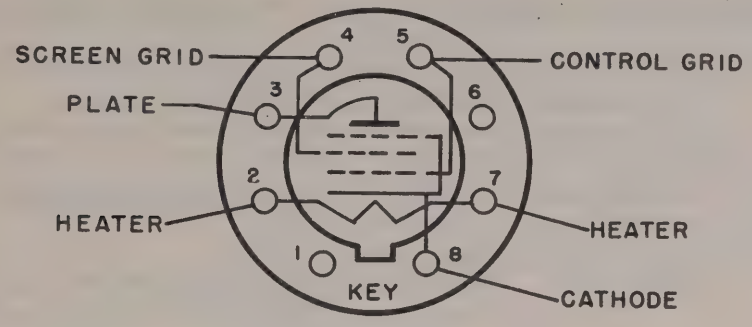
Characteristic	*As pentode*	*As triode (screen tied to plate)*
Plate voltage	300 max v	180 max v
Screen voltage	250 max v	
Plate dissipation	2.75 max w	2.5 max w
Screen dissipation	0.75 max w	

Typical operation and characteristics as Class A amplifier:

Characteristic	*As pentode*		*As triode*
Plate voltage	135 v	180 v	180 v
Screen voltage	135 v	180 v	
Grid voltage	—6 v	—9 v	—12 v
Peak a-f grid voltage	6 v	9 v	12 v
Amplification factor			9.5
Plate current (no signal)	11.5 ma	15 ma	11 ma
Screen current (no signal)	2 ma	2.5 ma	
Plate resistance	0.1 meg	0.175 meg	4,750 ohms
Transconductance	2,100 mhos	2,300 mhos	2,000 mhos
Load resistance	12,000 ohms	10,000 ohms	12,000 ohms
Total harmonic distortion	7.5%	10%	5%
Max signal power output	0.6 w	1.1 w	0.25 w

45. VACUUM-TUBE SOCKET CONNECTIONS.

The vacuum-tube socket connections for the tubes used in Telephone Repeater TP-14 are shown in figure 18.



VACUUM TUBE 6G6-G (VT-198-A)

BOTTOM VIEW OF SOCKET

TABLE OF EXTERNAL CONNECTIONS

FROM TERMINAL	ON VI A		ON VI B	
	THROUGH	TO	THROUGH	TO
1				
2		# 2 ON P. S. TERM. BOARD		# 1 ON P. S. TERM. BOARD
3		# 11 ON T2 A		# 11 ON T2 B
4		# 10 ON T2 B		# 10 ON T2 A
5		TERM. # 12 SEC 2 ON S4 A		TERM. # 12 SEC 2 ON S4 B
6		# 7 ON T1 A		GND. ON T1 B
		TERM. # 2 ON C21 A		TERM. # 2 ON C21 B
7		# 7 ON VI B		# 7 ON VI A
8		TERM. # 1 ON C21 A		TERM. # 1 ON C21 B
	R49 A	TO VI A # 6	R49 B	TO VI B # 6

TL 52333-S

Figure 18. Vacuum tube socket wiring diagram.

SECTION V
SUPPLEMENTARY DATA

46. MAINTENANCE PARTS LIST FOR TELEPHONE REPEATER TP-14.

The following information was compiled on 22 February 1945. The appropriate section of the ASF Signal Supply Catalog for Telephone Repeater TP-14 is:

SIG 8—TP-14, Telephone Repeater TP-14, when published.

For the latest index of available catalog sections, see ASF Signal Supply Catalog SIG 2.

Ref symbol	Signal Corps stock No.	Name of part and description
	4E926	BLOCK, protector: hard carbon; 1¼″ lg x ⅜″ wd x 5/32″ thk; WECo #26 (circuit protection).
	4E927	BLOCK, protector: grooved porcelain frame w/carbon insert held in place by fusible cement; 1¼″ lg x ⅜″ wd x 5/16″ thk overall (circuit protection).
	2Z9463.1	BOARD, terminal: 2 copper solder lug terminals; bakelite; 1¾″ lg x ⅝″ wd x ⅛″ thk; Jones #2-50; Fed Tele & Rad #W28-15.
	2Z9403.57	BOARD, terminal: 3 copper solder lug terminals; paper base bakelite XXP; 1⅞″ lg x ⅜″ wd x 3/32″ thk; Jones #3-3; Fed Tele & Rad dwg #WTA-3562, part #W28-60.
	3H4390-15	CABLE ASSEMBLY, power: general purpose; rubber jacketed; round; 0.31″ diam x 6 ft 9″ lg; two #18 AWG copper conductors ea comprising 16 #30 AWG strands; equipped w/Hubbell #7057 plug cap on one end; Fed Tele & Rad dwg #WTA-3510, part #W93-7.
C25, C26	3DB25-56	CAPACITOR, fixed: electrolytic; 25 mf +150% −10%; 300 vdcw; 3″ lg x 1″ diam; Dubilier #WP4A-583 (power supply filter).
C-23	3DB1000-4	CAPACITOR, fixed: electrolytic; 1000 mf +65% −10%; 25 vdcw; 3″ lg x 1⅜″ diam; Mallory FPS-059 (power supply filter).
C22A, C22B	3DB2.102	CAPACITOR, fixed: paper; 2 mf ±5%; 500 vdcw; 2¾″ wd x 2⅝″ lg x 1⅛″ h overall; Amcon per Fed Tele & Rad dwg WTA-1087, part #W3-102 (bypass circuit).
C21A, C21B	3DB2.68-1	CAPACITOR, fixed: paper; 2 mf +20% −10%; 500 vdcw; 2¾″ wd x 2⅝″ lg x 1⅛″ h overall; Amcon per Fed Tele & Rad dwg #WTA-1087, part #W3-68 (cathode bypass).

46. MAINTENANCE PARTS LIST FOR TELEPHONE REPEATER TP-14 (contd).

Ref symbol	Signal Corps stock No.	Name of part and description
C16A, C16B	3DA20-133	CAPACITOR, fixed: paper; 20,000 mmf ±5%; 600 vdcw; 1 9/16" x 2 1/2" x 13/16"; Amcon per Fed Tele & Rad dwg # WTA-3723, part W3-122 (equalizer).
C24	3DA100-373	CAPACITOR, fixed: paper; 100,000 mmf +20% −10%; 1000 vdcw; 1 9/16" x 2 1/2" x 13/16"; Amcon per Fed Tele & Rad dwg # WTA-2723, part W3-123 (buffer).
C17A, C18A, C17B, C18B	3DA40-20	CAPACITOR, fixed: paper; 2 section; 30,000-40,000 mmf ±5%; 600 vdcw; 1 9/16" x 2 1/2" x 13/16"; Amcon per Fed Tele & Rad dwg # WTA-3524, part # W3-119 (equalizer circuit).
C7A, C8A, C7B, C8B	3DA150-13	CAPACITOR, fixed: paper; 2 section, 150,000-150,000 mmf ±5%; 600 vdcw; 1 9/16" x 2 1/2" x 13/16"; Amcon per Fed Tele & Rad dwg # WTA-3524, part # W3-108 (network).
C14A, C15A, C14B, C15B	3DA200-35	CAPACITOR, fixed: paper; 2 section; 150,000-200,000 mmf ±5%; 600 vdcw; 1 9/16" x 2 1/2" x 13/16"; Amcon per Fed Tele & Rad dwg # WTA-3524, part # W3-118 (equalizer circuit).
C6A, C6B, C10A, C10B	3DA200-34	CAPACITOR, fixed: paper; 2 section, 200,000-200,000 mmf ±5%; 600 vdcw; 1 9/16" x 2 1/2" x 13/16"; Amcon per Fed Tele & Rad dwg # WTA-3524, part # W3-107 (network).
C19A, C20A, C9A, C9B, C12A, C12B	3DA300-13	CAPACITOR, fixed: paper; 2 section; 200,000-300,000 mmf ±5%; 600 vdcw; 1 9/16" x 2 1/2" x 13/16"; Amcon per Fed Tele & Rad dwg # WTA-3524, part # W3-106 (network).
C11A, C11B, C13A, C13B	3DA500-286	CAPACITOR, fixed: paper; 2 section; 300,000-500,000 mmf ±5%; 600 vdcw; 2 3/4" x 2 9/16" x 3/4"; Amcon per Fed Tele & Rad dwg # WTA-3525, part # W3-109 (network).
C1A, C1B, C2A, C2B, C3A, C3B C4A, C4B, C5A, C5B	3DA60-12	CAPACITOR, fixed: paper; 5 section; 15,000-30,000-45,000-60,000-120,000 mmf ±10%; 600 vdcw; 3 1/4" x 2 3/4" x 3/4" overall; Amcon per Fed Tele & Rad dwg # WTA-3523, part # W3-105 (building out).

46. MAINTENANCE PARTS LIST FOR TELEPHONE REPEATER TP-14 (contd).

Ref symbol	Signal Corps stock No.	Name of part and description
	2Z2724-21	CLIP, earphone: 0.025″ phosphor bronze, nickel plated; 1 7/32″ lg x 5/16″ wd x 1/2″ h overall; Fed Tele & Rad dwg # WTA-2965, part # W60-10.
	2Z2635.89	CLAMP, capacitor: aluminum alloy; split collar type w/1 clamp bolt; 1″ diam, 0.032 thk; Fed Tele & Rad dwg # WTA-2525, part # W50-26.
	2Z2635.88	CLAMP, capacitor: aluminum alloy; split collar type w/1 clamp bolt; 1 3/8″ diam, 0.032″ thk; Fed Tele & Rad dwg # WTA-2525, part # W50-41.
	2Z2635.90	CLAMP, capacitor: aluminum alloy; split collar type w/1 clamp bolt; 1 1/2″ diam, 0.032″ thk; Fed Tele & Rad dwg # WTA-2525, part # W50-43.
L1	3C315-52	COIL, AF: filter; single winding; 400 mh; 1 amp, 1.8 ohms; 2 9/16″ lg x 2 1/4″ wd x 1 15/16″ h overall; Fed Tele & Rad dwg # WTA-71210, part # W12-10 (power supply filter).
L2	3C315-23	COIL, AF: filter; single winding; 9,300 mh; 3 v DC; 25 ma; 120 ohms; 2 3/16″ x 1 3/16″ sq overall; Fed Tele & Rad dwg # WTA-71208, part # W12-8 (power supply filter).
L4A, L4B	3C315-77	COIL, AF: filter; 2 windings; winding 1-2, 43 mh, 1.2 max nominal v, 400 ma, 2.85 ohms; winding 3-4, 30 mh, 1.3 max nominal v, 300 ma, 4.17 ohms; 3″ h x 1 3/4″ sq overall; Fed Tele & Rad dwg # WTA-71232, part # W12-32 (equalizer).
L3	3C315-78	COIL, AF: filter; 2 balanced windings; 1,600 mh; 1 v DC; 12.5 ma, 600 ohms ea; 2 1/8″ h x 1 5/8″ sq overall; Fed Tele & Rad dwg # WTA-71231, part # W12-31 (used to derive simplex circuits).
T4	3C315-79	COIL, repeating: 4 windings; windings 1-2 and 3-4, 35 ohms; windings 5-6 and 7-8, 42 ohms; 2 1/2″ lg x 2.187″ wd x 2 11/16″ h overall; Fed Tele & Rad dwg # WTA-71565, part # W15-65 (used to derive simplex circuits).

46. MAINTENANCE PARTS LIST FOR TELEPHONE REPEATER TP-14 (contd).

Ref symbol	Signal Corps stock No.	Name of part and description
F3	3Z2576-1	FUSE, cartridge: 1/16 amp, 250 v; one time; glass body; 1/4" diam x 1 1/4" lg overall; Littelfuse # 1322.
F1	3Z1946	FUSE, cartridge: Sig C Fuse FU-46; 1/2 amp; 250 v; one time; glass body; 1/4" diam x 1 1/4" lg overall; Littelfuse # 1046.
F2	3Z1927	FUSE, cartridge: Sig C Fuse FU-27; 2 amp, 250 v; one time; glass body; 1/4" diam x 1 1/4" lg overall; Littelfuse # 1042.
	4Z4380	GASKET, amber gum: seals cover to case; 7/32" OD x 55" lg, 3/64" walls; Minor Rub per Fed Tele & Rad # W38-10.
	3Z275-9	HOLDER, fuse: extractor post; for single 3AG fuse; 3/4" diam x 2 5/8" overall; Littelfuse # SP-96.
	3G1838-36.12	INSULATOR, socket: oval; brown bakelite; 2 1/4" x 1 5/8" x 1/32" overall; Ucinite # 115016-1; Fed Tele & Rad # W74-62 (for 4 prong vibrator socket).
	2Z5786.41	KNOB, bar: molded black phenolic; for 1/4" diam shaft; single # 6-32 x 3/16" Fil H screw; approx 1 5/8" lg x 1/2" h overall; Fed Tele & Rad dwg # WTA-3579, part # W26-12.
	2Z5786.42	KNOB, round: molded black phenolic; for 1/4" diam shaft; single # 6-32 Fil H screw; white arrow marking; 1 1/4" diam x 5/8" overall; Fed Tele & Rad dwg # WTA-3533, part # W26-11.
	6D16823-1	LABEL, circuit and instruction: vinylite; 9 13/16" wd x 15 5/8" lg x 0.025" thk; Fed Tele & Rad dwg # WTB-3591, part # W63-45.
	3Z246	POST, binding: Sig C Binding Post TM-146; brass w/rubber head; 1/2" diam x 3/4" h closed, above panel; Eby "Sergeant SS" without lock pin; Fed Tele & Rad dwg # WTA-1090, part # W27-3; SC-D-530 (line, simplex, ground, monitor connections).

46. MAINTENANCE PARTS LIST FOR TELEPHONE REPEATER TP-14 (contd).

Ref symbol	Signal Corps stock No.	Name of part and description
	3Z246A	POST, binding: Sig C Binding Post TM 146-A; brass w/rubber head; ½″ diam x ¾″ h closed, above panel; Eby "Sergeant SS" w/locking pin; Fed Tele & Rad dwg #WTA-1090, part #W27-2; SC-D-530 (external battery connection).
	3Z244	POST, binding: Sig C Binding Post TM-144; brass; ⅜″ diam x 9/16″ h closed; Eby "Corporal"; Fed Tele & Rad dwg #WTA-1090, part #W27-1; SC-D-530 (external network connection).
	4E4550	PROTECTOR, lightning: consisting of steel holder & cover assembled w/2 ea WECo #26 & #27 protector blocks, cont springs and insulator; approx 2 1/16″ lg x 1⅜″ wd x 29/32″ overall, less mtg screws; Fed Tele & Rad dwg #WTB-4042, part #W92-203.
	4B3030.1	RECEIVER, headset: black bakelite; 7,500 ohms; 2½″ diam; Trimm #161 w/Buna "S" cord insulation; Fed Tele & Rad #W66-14.
Rect	3H4838-16	RECTIFIER, metallic: selenium; input 180 v AC 50-60 cyc; output 173 v DC, 25 ma max; round 1″ diam x 4¼″ lg overall; Fed Tele & Rad #2D1084.
R8A, R8B, R9A, R9B, R14A, R14B, R15A, R15B, R16B, R17A, R17B	3RC20AE100J	RESISTOR, fixed: carbon; 10 ohm ±5%; ½ w; 9/64″ diam x ⅜″ lg; RC20AE100J (network circuit).
R10A, R10B	3RC20BE150J	RESISTOR, fixed: carbon; 15 ohm ±5%; ½ w; 9/64″ diam x ⅜″ lg; RC20BE150J (network circuit).
R11A, R11B, R12A, R12B, R18A, R18B	3RC20AE300J	RESISTOR, fixed: carbon; 30 ohm ±5%; ½ w; 9/64″ diam x ⅜″ lg; RC20AE300J (equalizer and network).

46. MAINTENANCE PARTS LIST FOR TELEPHONE REPEATER TP-14 (contd).

Ref symbol	Signal Corps stock No.	Name of part and description
R19A, R19B, R20A, R20B, R21A, R21B, R22A, R22B, R23A, R23B, R24A, R24B, R25A, R25B	3RC20AE510J	RESISTOR, fixed: carbon; 51 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE510J (network circuit).
R35A, R35B, R26A, R26B, R28A, R28B, R27A, R27B, R29A, R29B, R38A, R38B	3RC20AE101J	RESISTOR, fixed: carbon; 100 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE101J (network).
R32A, R32B	3RC20AE121J	RESISTOR, fixed: carbon; 120 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE121J (network).
R2A, R2B	3RC20AE201J	RESISTOR, fixed: carbon; 200 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE201J (network).
R5A, R5B, R36A, R36B	3RC20AE241J	RESISTOR, fixed: carbon; 240 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE241J (network).
R31A, R31B	3RC20AE271J	RESISTOR, fixed: carbon; 270 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE271J (network).
R37A, R37B, R6A, R6B	3RC20AE301J	RESISTOR, fixed: carbon; 300 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE301J (network).
R33A, R33B	3RC20BE431J	RESISTOR, fixed: carbon; 430 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20BE431J (network).
R3A, R3B	3RC20AE621J	RESISTOR, fixed: carbon; 620 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE621J (network).
R49A, R49B	3RC20AE751J	RESISTOR, fixed: carbon; 750 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE751J (cathode bias).
R4A, R4B	3RC20BE911J	RESISTOR, fixed: carbon; 910 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20BE911J (network).

46. MAINTENANCE PARTS LIST FOR TELEPHONE REPEATER TP-14 (contd).

Ref symbol	Signal Corps stock No.	Name of part and description
R43A, R43B	3RC20AE163J	RESISTOR, fixed: carbon; 16,000 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE163J.
R21A, R21B	3RC20AE222J	RESISTOR, fixed: carbon; 2,220 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE222J (network).
R34A, R34B	3RC20AE242J	RESISTOR, fixed: carbon; 2,400 ohms ±5%; ½ w; 3/8″ lg x 9/64″ diam; RC20AE242J (network).
R40A, R40B	3RC20AE822J	RESISTOR, fixed: carbon; 8,200 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE822J (gain control).
R41A, R41B	3RC20AE103J	RESISTOR, fixed: carbon; 10,000 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE103J (gain control).
R42A, R42B	3RC20AE133J	RESISTOR, fixed: carbon; 13,000 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE133J (gain control).
R44A, R44B, R50A, R50B	3RC20AE203J	RESISTOR, fixed: carbon; 20,000 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE203J (gain control and talk circuit).
R45A, R45B	3RC20AE273J	RESISTOR, fixed: carbon; 27,000 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE273J (gain control).
R39A, R39B, R46A, R46B	3RC20AE333J	RESISTOR, fixed: carbon; 33,000 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE333J (gain control).
R47A, R47B	3RC20AE433J	RESISTOR, fixed: carbon; 43,000 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE433J (gain control).
R48A, R48B	3RC20AE513J	RESISTOR, fixed: carbon; 51,000 ohms ±5%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE513J (gain control).
R51, R52	3RC20AE823K	RESISTOR, fixed: carbon; 82,000 ohms ±10%; ½ w; 9/64″ diam x 3/8″ lg; RC20AE823K (power supply bleeder).
R7A, R7B	3Z6006E5-6	RESISTOR, fixed: wire wound; 65 ohms ±1%; ½ w; 1/8″ diam x 1″ lg; Precision Resistor Co type TW; Fed Tele & Rad # W8-73 (network circuit).

46. MAINTENANCE PARTS LIST FOR TELEPHONE REPEATER TP-14 (contd).

Ref symbol	Signal Corps stock No.	Name of part and description
R13A, R13B	3Z6022-47	RESISTOR, fixed: wire wound; 220 ohms ±1%; ½ w; ⅛" diam x 1" lg; Precision Resistor Co type TW; Fed Tele & Rad # W8-74 (network circuit).
	6Z8448-5	STRAP, carrying: olive drab cotton webbing; 10 ft lg x 2" wd; Fed Tele & Rad dwg # PC-3578, part # W92-354; Sig C specs 6-185 and 72-53.
S7	3Z9825-62.161	SWITCH, rotary: single pole, 3 position; 1 section; bakelite body; 1⅞" diam x 1½" lg overall; Oak # 28240-27; Fed Tele & Rad dwg # WTB-3507, part # W20-45 (talk and monitor switch).
S4A, S4B	3Z9825-62.159	SWITCH, rotary: single pole, 11 position; 2 section; bakelite body; 1⅞" diam x 2½" lg overall; Oak # 28236-H2; Fed Tele & Rad dwg # WTB-3501, part # W20-39 (gain control).
S3A, S3B	3Z9825-62.160	SWITCH, rotary: single pole, 12 position; special 1 section; bakelite body; 1⅞" diam x 1⅝" lg overall; Oak # 28238-H1; Fed Tele & Rad dwg # WTB-3503, part # W20-41 (building out capacitor switch).
S2A, S2B	3Z9825-62.163	SWITCH, rotary: single pole, 24 position; 2 section, bakelite body; 1⅞" diam x 2⅝" lg overall; Oak # QH-28267; Fed Tele & Rad dwg # WTB-3508, part # W20-47 (line balancing network).
S8	3Z9825-62.162	SWITCH, rotary: 3 pole, 2 position; 2 section; bakelite body; 1⅞" diam x 1⅞" lg overall; Oak # 28241-54; Fed Tele & Rad # W20-44 (off-on power switch).
S6	3Z9825-62.158	SWITCH, rotary: 4 pole, 4 position; bakelite insulation; 1⅞" diam x 1⅞" lg overall; Oak # 28235-H2; Fed Tele & Rad # W20-43 (voltage selector).
S5A, S5B	3Z9825-62.164	SWITCH, rotary: 5 pole, 3 position; 2 section; bakelite body; 1⅞" diam x 2⅝" lg overall; Oak # 28404-H2; Fed Tele & Rad dwg # WTA-3502, part # W20-40 (equalizer switch).

46. MAINTENANCE PARTS LIST FOR TELEPHONE REPEATER TP-14 (contd).

Ref symbol	Signal Corps stock No.	Name of part and description
S1A, S1B	3Z9825-62:166	SWITCH, rotary: 12 position; special; 3 section; bakelite body; 2⅛" diam x 2⅝" lg overall; Oak #28529-H4; Fed Tele & Rad dwg #WTB-3504, part #W20-42 (line balancing network).
	2Z8674.117	SOCKET, tube: 4 prong wafer; porcelain body; 2⅜" diam x ⅝" h overall; Ucinite #115028-C; Fed Tele & Rad #W17-30 (vibrator socket).
	2Z8678.195	SOCKET, tube: octal; porcelain body; 1⅝" diam x 1" h overall; Ucinite #115001-1A; Fed Tele & Rad #W17-32.
T1A, T1B	2Z9631.228	TRANSFORMER, AF: input; consists of high impedance and low impedance windings; winding 1-2 and 3-4, 75 ohms; winding 5-6, 300 ohms; winding 7-8 and 9-10, 600 ohms; winding 11-12, 250,000 ohms impedance; shielded steel shell; 2⅝" h x 1 11/16" sq overall; Fed Tele & Rad part #W15-75.
T2A, T2B	2Z9632.319	TRANSFORMER, AF: output; winding 1-2, 75 ohms; winding 3-4, 75 ohms; winding 5-6, 300 ohms; winding 7-8, 20 ohms; winding 7-9, 300 ohms; winding 10-11, 13,000 ohms impedance; 2⅝" h x 1 11/16" sq overall; Fed Tele & Rad dwg #WTA-71576, part #W15-76.
T3	2Z9613.359	TRANSFORMER, power: filament and plate; completely enclosed metal case; 2.875" lg x 2.750" wd x 3½" h; Fed Tele & Rad dwg #WTA-71578, part #W15-78.
V1-A, V1-B, V spare	2J6G6G	TUBE, electron: JAN 6G6-G (VT-198-A).
VIB	3H6691-14	VIBRATOR, non-synchronous: input; 12 v, ½ amp; tubular aluminum can; 1½" diam x 3 7/16" lg overall; Oak #6197; Fed Tele & Rad #W11-6.

NOTES

NOTES

U. S. GOVERNMENT PRINTING OFFICE : O 1949

TRANS-WORLD ELECTRONICS CO.

New York 3, N. Y.

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U. S. GOVERNMENT PRINTING OFFICE · O 1949

INSTALLATION AND OPERATION - TELEPHONE REPEATER TP-14

FOR COMPLETE OPERATING INSTRUCTIONS SEE TM 11-2007

1. INSTALLATION.

a. Connect ARRESTER GROUND binding post 14 to a good ground. Make sure the protector blocks are clean.

b. Check that the power source is connected properly and that the VOLTAGE SELECTOR switch is set to correspond with the type of power being used, as follows; and then operate POWER switch to ON:

(1) A-C Operation.

(a) Set the VOLTAGE SELECTOR switch at 115 or 230, depending on the voltage of the local supply.

(b) Plug power cord into local supply.

(2) 12-Volt Storage Battery Operation.

(a) Set VOLTAGE SELECTOR switch at 12.

(b) Connect a 12-volt storage battery, or two 6-volt storage batteries in series, to the BAT binding posts +12 and −(1 and 2). Use short lengths of #12 gauge, or larger, insulated copper wire.

MAKE SURE THAT THE POSITIVE TERMINAL OF THE BATTERY CONNECTS TO THE +12 BINDING POST.

(3) External Dry Battery Operation.

(a) Set VOLTAGE SELECTOR switch to EXT.

(b) Connect positive terminal of a 135-volt battery to the +135 binding post 3 and connect the negative terminal of the battery to the negative terminal of a 12-volt battery and then to the −binding post 2. Connect the positive terminal of the 12-volt battery to the +12 binding post 1. (135 volt battery drain is 18-20 ma, 12 volt battery drain is 150 ma).

c. Simplex Connections. If the simplex circuit from either the A or B direction is terminated at the repeater, connect the simplex equipment to the SX binding post 4-5 or 12-13 as required. Remove the strap between these binding posts.

2. REPEATER CONNECTIONS AND SWITCH SETTINGS.

a. As an Intermediate Repeater.

(1) Connect the line from direction A to the LINE A binding posts 4 and 5 and the line from direction B to LINE B binding posts 12 and 13.

(2) Set the NET A-1, NET A-2, NET B-1, NET B-2, EQL-AB, and EQL-BA switches to correspond with the line facilities as covered in the table of "Network and Equalizer Adjustments." If the particular line facility employed is not covered in this table, set the EQL-AB and EQL-BA switches temporarily at 1.

(3) Set the GAIN-AB and GAIN-BA switches to correspond with the gains specified for each direction of transmission. If no gain settings have been specified, determine the settings in accordance with the procedure outlined in paragraphs 5a and 5b.

(4) Listen with the monitoring receiver. If the repeater does not "sing" advance switches GAIN-AB and GAIN-BA each one step and again listen for "singing." If repeater does not "sing" in this condition return gain switches to their specified positions. If repeater "sings" reduce each gain switch setting until "singing" stops. Then set each switch one step lower.

b. As a Terminal Repeater.

(1) Connect the outgoing line to either the LINE A binding posts 4 and 5 or LINE B binding posts 12 and 13. Set the associated network and equalizer switches to correspond with the settings for the outgoing line facility.

(2) Connect the other set of line binding posts to the switchboard circuit. Set the corresponding NET A-1, or NET B-1 switch at 10, the NET A-2 or NET B-2 switch at 15, and EQL-AB or EQL-BA switch to 1.

(3) Adjust the gain as described in paragraphs 2a(3) and 2a(4).

3. EXTERNAL BALANCING NETWORKS.

a. When external balancing networks are to be used, connect them to the EXT NET A binding posts 6 and 7, the EXT NET B binding posts 10 and 11 or both, as required.

b. Set the NET A-1, NET A-2, (or NET B-1, NET B-2, or both) switches at EXT.

4. REPEATER GAIN CHECK.

a. Set the NET A-1 and NET B-1 switches at 11 and the NET A-2 and NET B-2 switches at 15.

b. Set both switches GAIN-AB and GAIN-BA at X.

c. Set both switches EQL-AB and EQL-BA at 1.

d. Strap LINE A binding post 5 to LINE B binding post 12 and strap LINE A binding post 4 to LINE B binding post 13.

e. Turn the GAIN-AB switch slowly clockwise, listening in the receiver for "singing" and note the switch setting at which "singing" starts. Restore the switch to position X.

f. Repeat operation 4e using the GAIN-BA switch.

g. If repeater does not sing with the gain switches at 0 or 2, check power source, fuses, tubes, monitoring receiver, and protector blocks.

h. Remove the straps between the line binding posts.

5. GAIN SWITCH SETTINGS.

a. If no gain settings have been specified, set the GAIN-AB and GAIN-BA switches at X and set the network and equalizer switches in accordance with the table of "Network and Equalizer Adjustments" for the particular line facility.

b. Advance both the GAIN-AB and GAIN-BA switches one step at a time, alternately, and listen with the receiver for "singing." When "singing" occurs, reduce the setting of each gain switch by two steps to provide proper singing margin.

6. MONITORING, TALKING AND RINGING.

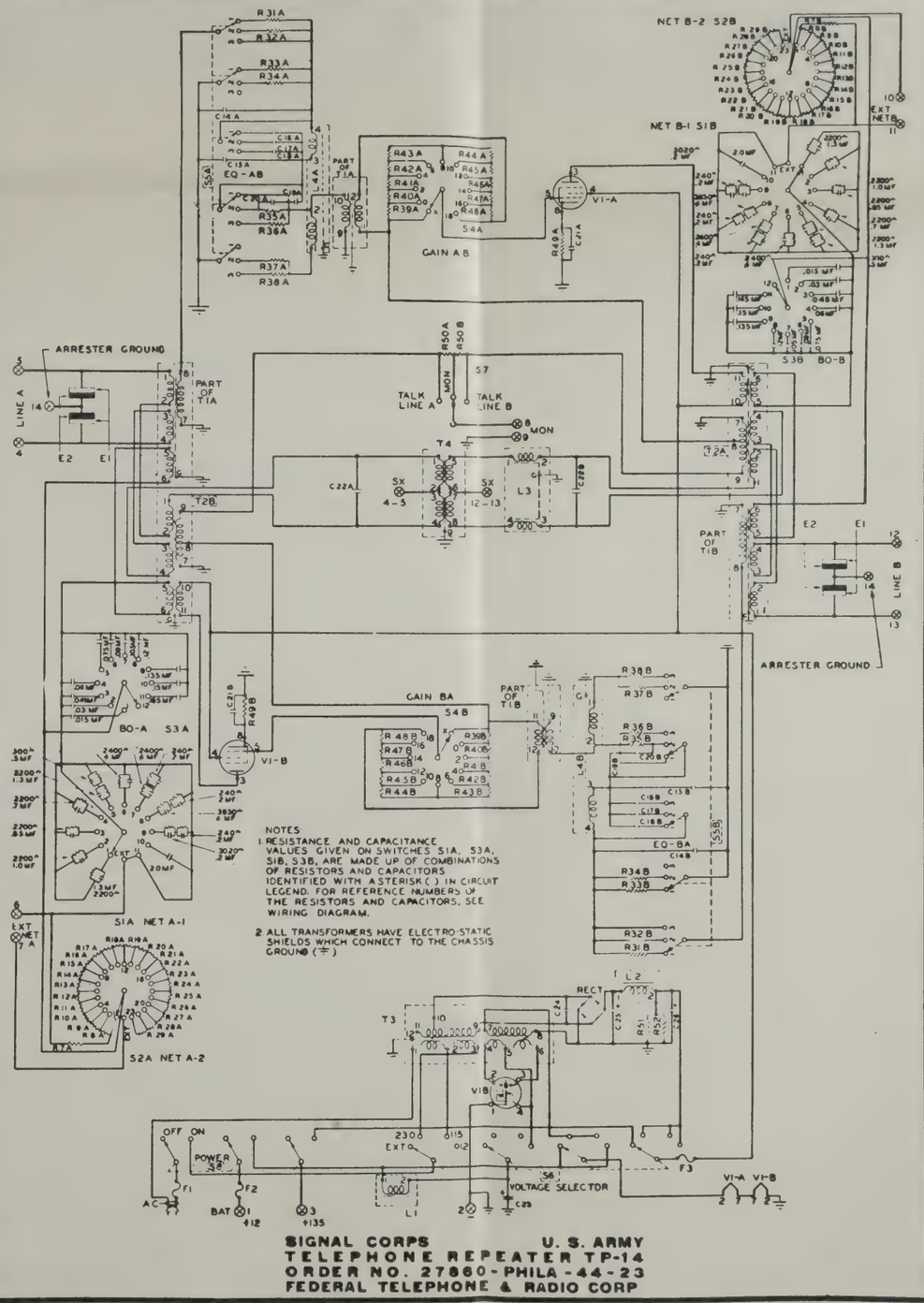
a. To monitor the communication in both directions, connect the receiver to the MON binding posts 8 and 9 and listen.

b. To talk from the repeater station to the A or B terminal, connect a Telephone EE-8-( ) to the MON binding posts 8 and 9. Operate the MON switch to the appropriate talk position. Keep the handset switch operated while talking. To listen, release the handset switch and the MON switch. CAUTION: DO NOT ATTEMPT TO RING FROM A TELEPHONE CONNECTED TO THE MON BINDING POSTS.

c. To ring from repeater station, turn both gain switches to 0, connect Telephone EE-8-( ) to LINE A binding posts 4 and 5, or LINE B binding posts 12 and 13, and ring. Normal conversation can be carried on without restoring the telephone to the MON binding posts 8 and 9. Remove Telephone EE-8-( ) and restore gain switches to their normal positions at conclusion of the conversation.

7. BUILDING-OUT CAPACITORS.

a. The building-out capacitor associated with each balancing network is not required except when a short length (not exceeding one mile) of non-loaded entrance cable intervenes between the repeater and an adjacent main line section. In such a case, advance the BO-A or BO-B switch, starting with position 1, as required (roughly one step for each 500 feet of entrance cable). Set the BO-A or BO-B switch to the position which will allow specified repeater gain and singing margin. Otherwise, keep the BO-A and BO-B switches in position 12.



SIGNAL CORPS U. S. ARMY
TELEPHONE REPEATER TP-14
ORDER NO. 27860-PHILA-44-23
FEDERAL TELEPHONE & RADIO CORP

CIRCUIT LEGEND

					USED IN SWITCH POSITION
*R1 A & B	RES.	2,200 ohms	± 5 %	½ W	S1 7 to 9
*R2 A & B	"	290	"	"	S1 6 to 9
*R3 A & B	"	575	"	"	S1 0 and 5
*R4 A & B	"	910	"	"	S1 0
*R5 A & B	"	240	"	"	S1 7 to 9
*R6 A & B	"	380	"	"	S1 5
R7 A & B	"	85	"	1 W	
R8 A & B	"	10	± 5 %	½ W	
R9 A & B	"	10	"	"	
R10 A & B	"	15	"	"	
R11 A & B	"	30	"	"	
R12 A & B	"	30	"	"	
R13 A & B	"	220	"	1	
R14 A & B	"	10	± 5 %	½	
R15 A & B	"	10	"	"	
R16 A & B	"	10	"	"	
R17 A & B	"	10	"	"	
R18 A & B	"	30	"	"	
R19 A & B	"	51	"	"	
R20 A & B	"	51	"	"	
R21 A & B	"	51	"	"	
R22 A & B	"	51	"	"	
R23 A & B	"	51	"	"	
R24 A & B	"	51	"	"	
R25 A & B	"	51	"	"	
R26 A & B	"	100	"	"	
R27 A & B	"	100	"	"	
R28 A & B	"	100	"	"	
R29 A & B	"	100	"	"	
R31 A & B	"	270	"	"	
R32 A & B	"	120	"	"	
R33 A & B	"	430	"	"	
R34 A & B	"	2,400	"	"	
R35 A & B	"	100	"	"	
R36 A & B	"	240	"	"	
R37 A & B	"	360	"	"	
R38 A & B	"	100	"	"	
R39 A & B	"	33,000	"	"	
R40 A & B	"	6,200	"	"	
R41 A & B	"	14,000	"	"	
R42 A & B	"	12,000 ohms	± 5 %	½ W	
R43 A & B	"	16,000	"	"	
R44 A & B	"	20,000	"	"	
R45 A & B	"	27,000	"	"	
R46 A & B	"	33,000	"	"	
R47 A & B	"	43,000	"	"	
R48 A & B	"	51,000	"	"	
R49 A & B	"	750	"	"	
R50 A & B	"	20,000	"	"	
R51	"	62,000	± 10 %	½ W	
R52	"	82,000	"	"	

					USED IN SWITCH POSITION
*C1 A & B	CAP.	.045 mf.	± 10 %	600 VDCW	S3 1, 5, 9
*C2 A & B	"	.03 mf.	"	"	S3 2, 6, 10
*C3 A & B	"	.045 mf.	"	"	S3 3, 7, 11
*C4 A & B	"	.06 mf.	"	"	S3 4 to 7
*C5 A & B	"	.12 mf.	"	"	S3 8 to 11
*C6 A & B	"	.2 mf.	± 5 %	"	S1 1 to 10
*C7 A & B	"	.15 mf.	"	"	S1 1, 2, 3, 5, 10
*C8 A & B	"	.15 mf.	"	"	S3 1, 2, 5, 10
*C9 A & B	"	.3 mf.	"	"	S1 1, 5, 5, 10
*C10 A & B	"	.2 mf.	"	"	S1 1 to 8 and 10
*C11 A & B	"	.3 mf.	"	"	S1 1, 2, 4, 5, 10
*C12 A & B	"	.2 mf.	"	"	S1 7 to 10
*C13 A & B	"	.5 mf.	"	"	S1 5 and 10
C14 A & B	"	.15 mf.	"	"	
C15 A & B	"	.2 mf.	"	"	
C16 A & B	"	.02 mf.	"	"	
C17 A & B	"	.04 mf.	"	"	
C18 A & B	"	.03 mf.	"	"	
C19 A & B	"	.2 mf.	"	"	
C20 A & B	"	.3 mf.	"	"	
C21 A & B	"	2. mf.	+ 20 % − 10 %	300 VDCW	
C22 A & B	"	2. mf.	± 5 %	300 VDCW	
C23	"	1,000 mf.	+ 60 % − 10 %	25 VDCW	
C24	"	.1 mf.	+ 20 % − 10 %	1,000 VDCW	
C25	"	25. mf.	+ 100 % − 10 %	300 VDCW	
C26	"	25 mf.	"	"	

V1-A TUBE, ELECTRON, JAN 6C8-G
V1-B TUBE, ELECTRON, JAN 6C8-G
V1B VIBRATOR, 10K CYCLE

F1 FUSE, ½ AMP, 250 VOLT, FU-46
F2 FUSE, 2 AMP, 250 VOLT, FU-27
F3 FUSE, 1 ½ AMP, 250 VOLT

S1 A & B SWITCH, 12 POSITION, 3 SECTION
S2 A & B SWITCH, 1 POLE, 24 POSITION, 2 SECTION
S3 A & B SWITCH, 1 POLE, 12 POSITION, 1 SECTION
S4 A & B SWITCH, 1 POLE, 11 POSITION, 1 SECTION
S5 A & B SWITCH 5 POLE, 3 POSITION, 2 SECTION
S6 SWITCH, 4 POLE, 4 POSITION
S7 SWITCH, 1 POLE, 3 POSITION, 1 SECTION
S8 SWITCH, 3 POLE, 2 POSITION, 2 SECTION

RECT RECTIFIER, SELENIUM

T1A AND B, TRANSFORMER, AUDIO INPUT
T2A AND B TRANSFORMER, AUDIO OUTPUT
T3, TRANSFORMER, POWER
T4, REPEATING COIL

L1, COIL (POWER SUPPLY FILTER)
L2, COIL (POWER SUPPLY FILTER)
L3, COIL (SIMPLEX FILTER)
L4 A & B COIL (EQUALIZER)

E1, PROTECTOR BLOCK (PORCELAIN)
E2, PROTECTOR BLOCK (CARBON)

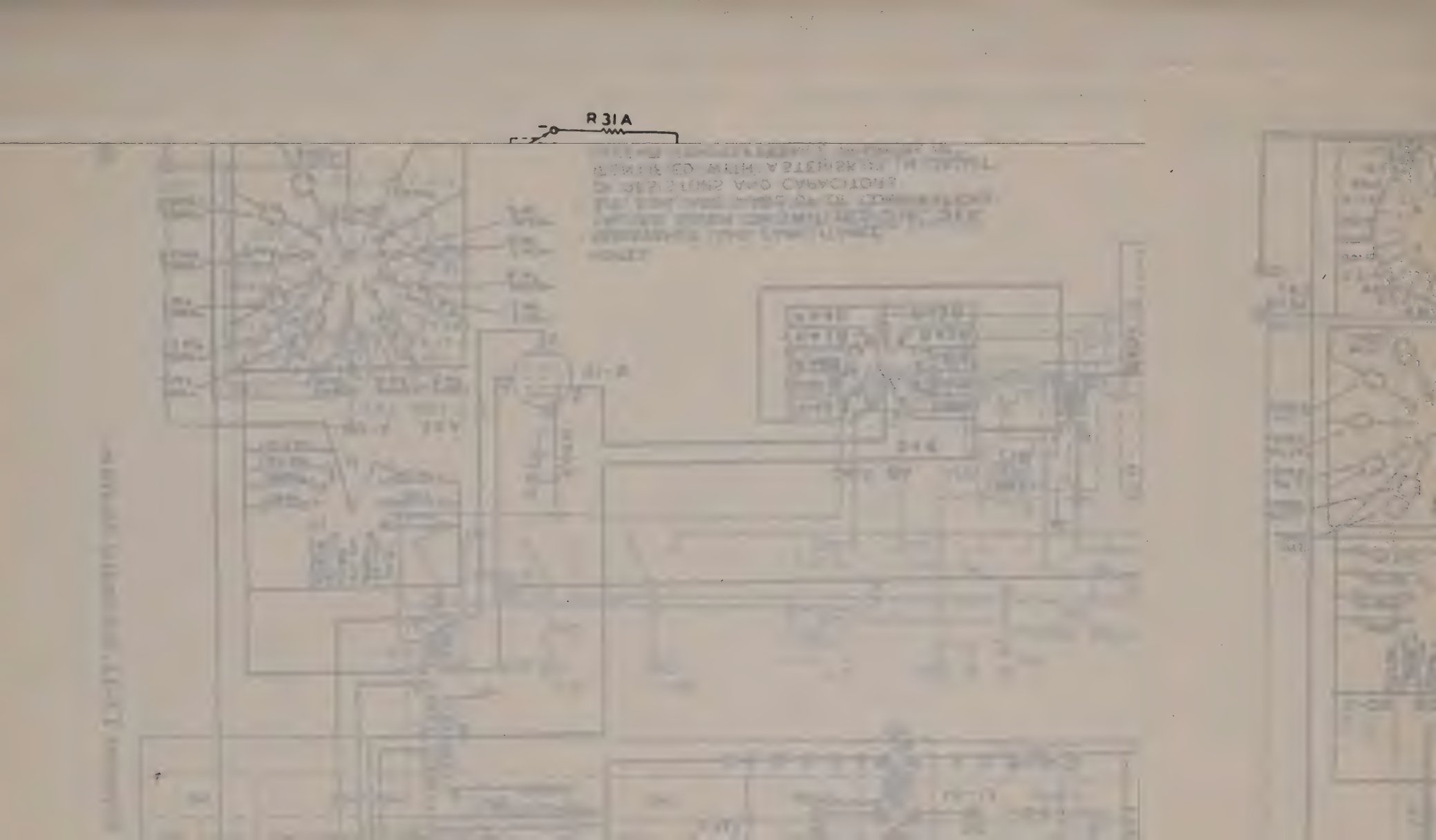
NETWORK AND EQUALIZER ADJUSTMENTS

FACILITY	NET A-1 or B-1	NET A-2 or B-2	EQL AB or BA
OPEN-WIRE ROADLOADED			
W-74 104 DIA. COPPER, SIDE	3	10	1
W-74 104 DIA. COPPER, PHANTOM	2	10	1
128 DIA. COPPER, SIDE	2	15	1
128 DIA. COPPER, PHANTOM	1	10	1
165 DIA. COPPER, SIDE	2	15	1
165 DIA. COPPER, PHANTOM	1	7	1
W-133 HI MIL COPPER STEEL, SIDE	0	13	1
104 DIA. COPPER STEEL, SIDE	6	15	2
104 DIA. COPPER STEEL, PHANTOM	4	10	1
W-145 109 DIA. STEEL, SIDE	0	20	2
W-116-S-12" SPACING, ON INSULATORS	0	15	1
FIELD WIRE AND CABLE			
W-110-B ROADLOADED, WET	6	6	3
W-110-B ROADLOADED, DAMP	7	4	3
W-110-B ROADLOADED, DRY	7	6	3
W-110-B LOADED 5309-88, WET	3	10	1
W-110-B LOADED 5309-88, DAMP	3	22	1
W-110-B LOADED 5309-88, DRY	4	22	1
W-143 ROADLOADED	3	3	3
W-143 LOADED 5309-44	1	13	3
WC-104, PAIR, ROADLOADED	5	4	3
CC-302, PAIR, LOADED 1539-6	2	12	1
16 OR 19 GA. CABLE, LOADED M-88, SIDE	3	22	1
19 OR 16 GA CABLE, LOADED M-92, PHANTOM	2	16	1
19 OR 19 GA. CABLE, LOADED M-94, SIDE	3	19	1
19 OR 16 GA. CABLE, LOADED M-25, PHANTOM	1	13	1
SWITCHBOARD OR TELEPHONE EE-8-( ) (AT A TERMINAL REPEATER)	10	15	1

NOTE: IN SOME CASES IT MAY BE NECESSARY TO SET THE NET A-2 OR NET B-2 SWITCH AT A POSITION OTHER THAN THAT SPECIFIED ABOVE TO IMPROVE THE BALANCE.

TL-52322 S

Figure 21. Telephone Repeater TP-14, operating and circuit label.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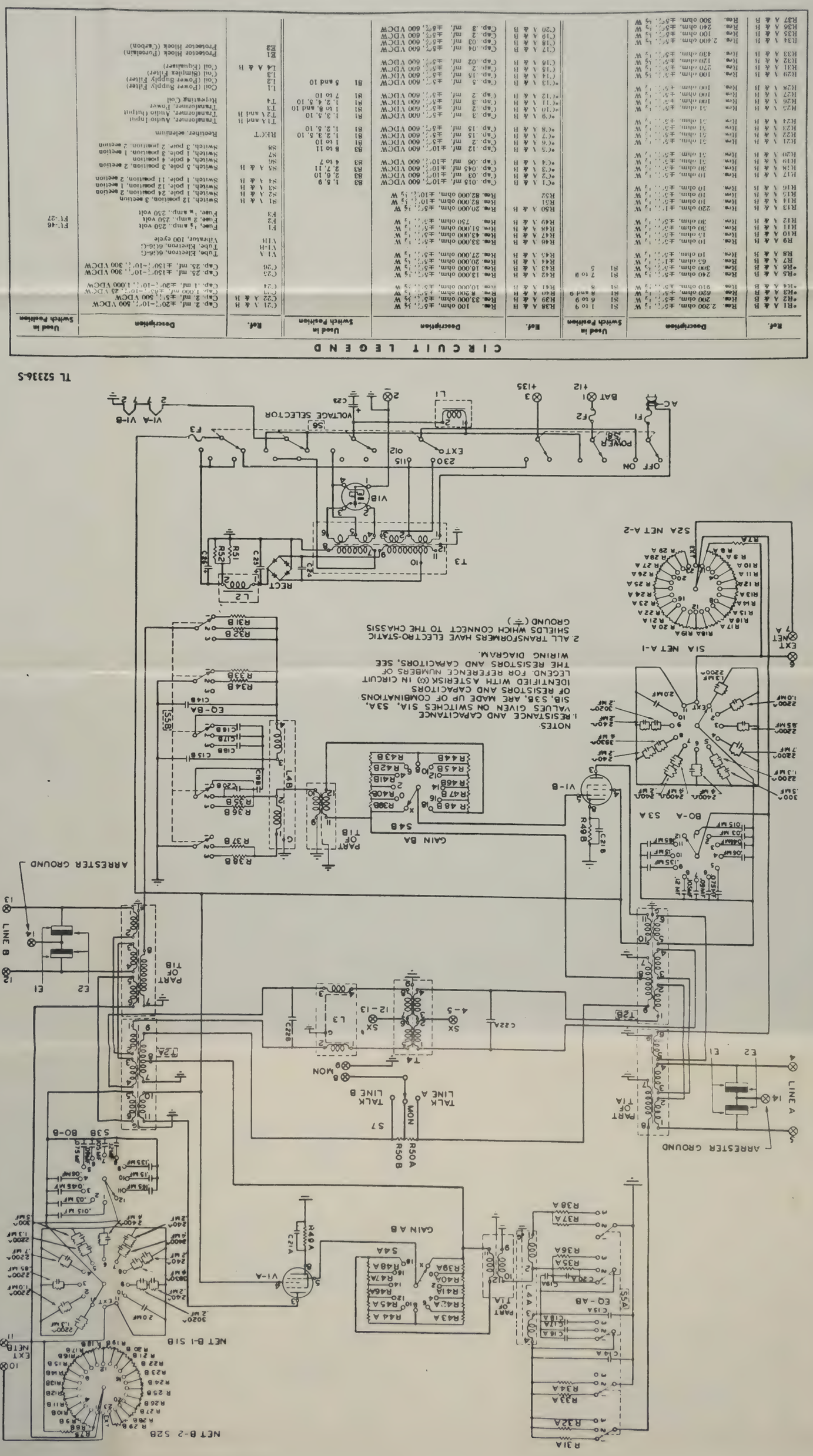


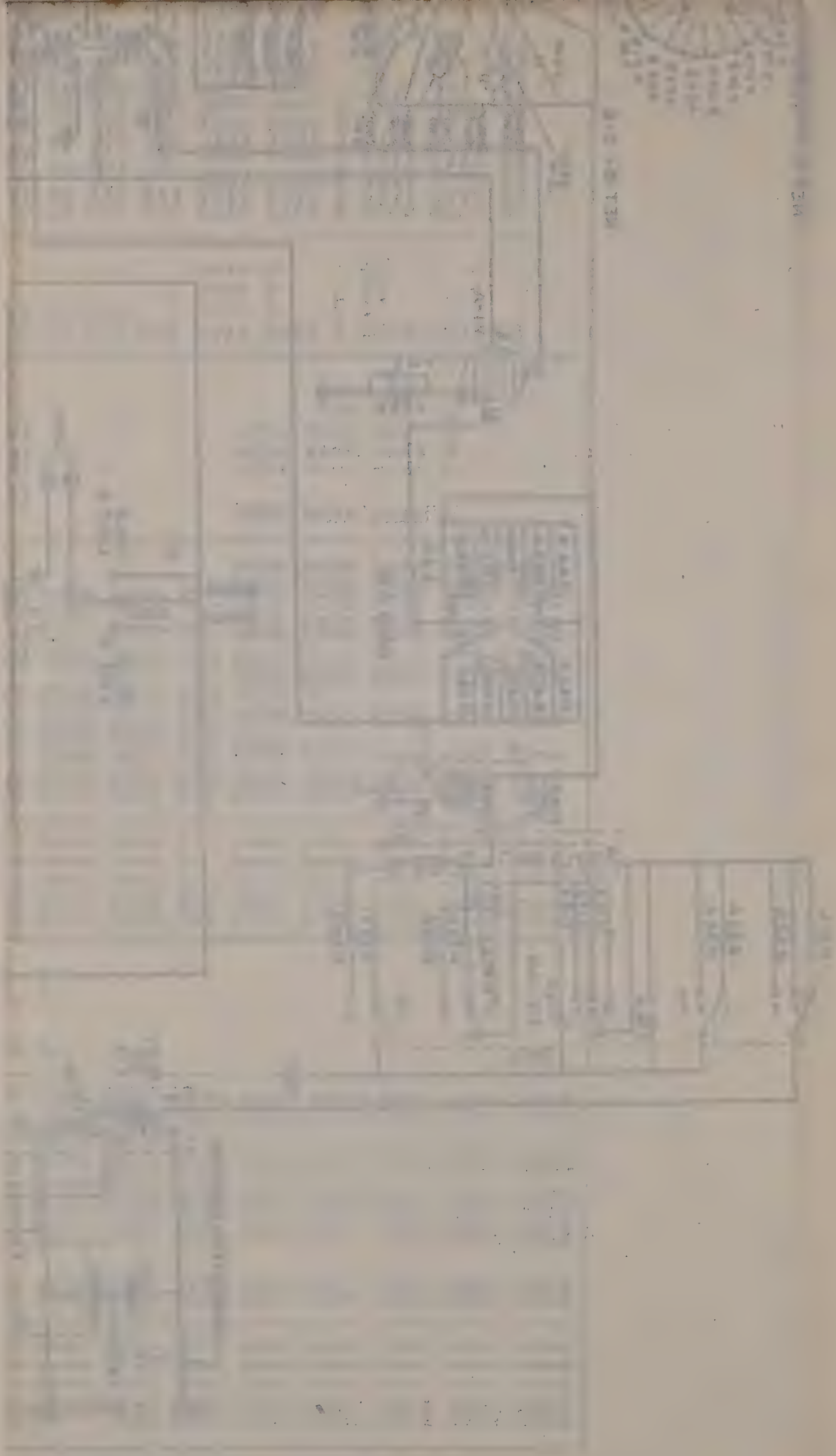
Ref.	Description	Used in Switch Position
*R1 A ✱ B	Res. 2,200 ohm, ±5%, ½ W	S1 1 to 9
*R2 A ✱ B	Res. 200 ohm, ±5%, ½ W	S1 A only
*R3 A ✱ B	Res. 620 ohm, ±5%, ½ W	S1 B only
*R4 A ✱ B	Res. 910 ohm, ±5%, ½ W	S1 A and B
R5 A ✱ B	Res. 2,400 ohm, ±5%, ½ W	S1 2 to 9
R6 A ✱ B	Res. 100 ohm, ±5%, ½ W	S1 1 to 9
R7 A ✱ B	Res. 63 ohm, ±1%, ½ W	S1 A only
*R8 A ✱ B	Res. 300 ohm, ±5%, ½ W	S1 B only
R9 A ✱ B	Res. 10 ohm, ±5%, ½ W	S1 A and B
R10 A ✱ B	Res. 15 ohm, ±5%, ½ W	
R11 A ✱ B	Res. 30 ohm, ±5%, ½ W	
R12 A ✱ B	Res. 30 ohm, ±5%, ½ W	
R13 A ✱ B	Res. 220 ohm, ±1%, ½ W	
R14 A ✱ B	Res. 10 ohm, ±5%, ½ W	
R15 A ✱ B	Res. 10 ohm, ±5%, ½ W	
R16 A ✱ B	Res. 10 ohm, ±5%, ½ W	
R17 A ✱ B	Res. 10 ohm, ±5%, ½ W	
R18 A ✱ B	Res. 30 ohm, ±5%, ½ W	
R19 A ✱ B	Res. 51 ohm, ±5%, ½ W	
R20 A ✱ B	Res. 51 ohm, ±5%, ½ W	
R21 A ✱ B	Res. 51 ohm, ±5%, ½ W	
R22 A ✱ B	Res. 51 ohm, ±5%, ½ W	
R23 A ✱ B	Res. 51 ohm, ±5%, ½ W	
R24 A ✱ B	Res. 51 ohm, ±5%, ½ W	
R25 A ✱ B	Res. 51 ohm, ±5%, ½ W	
R26 A ✱ B	Res. 100 ohm, ±5%, ½ W	
R27 A ✱ B	Res. 100 ohm, ±5%, ½ W	
R28 A ✱ B	Res. 100 ohm, ±5%, ½ W	
R29 A ✱ B	Res. 100 ohm, ±5%, ½ W	
R30 A ✱ B	Res. 120 ohm, ±5%, ½ W	
R31 A ✱ B	Res. 220 ohm, ±5%, ½ W	
R32 A ✱ B	Res. 120 ohm, ±5%, ½ W	
R33 A ✱ B	Res. 430 ohm, ±5%, ½ W	
R34 A ✱ B	Res. 2,400 ohm, ±5%, ½ W	
R35 A ✱ B	Res. 100 ohm, ±5%, ½ W	
R36 A ✱ B	Res. 260 ohm, ±5%, ½ W	
R37 A ✱ B	Res. 300 ohm, ±5%, ½ W	

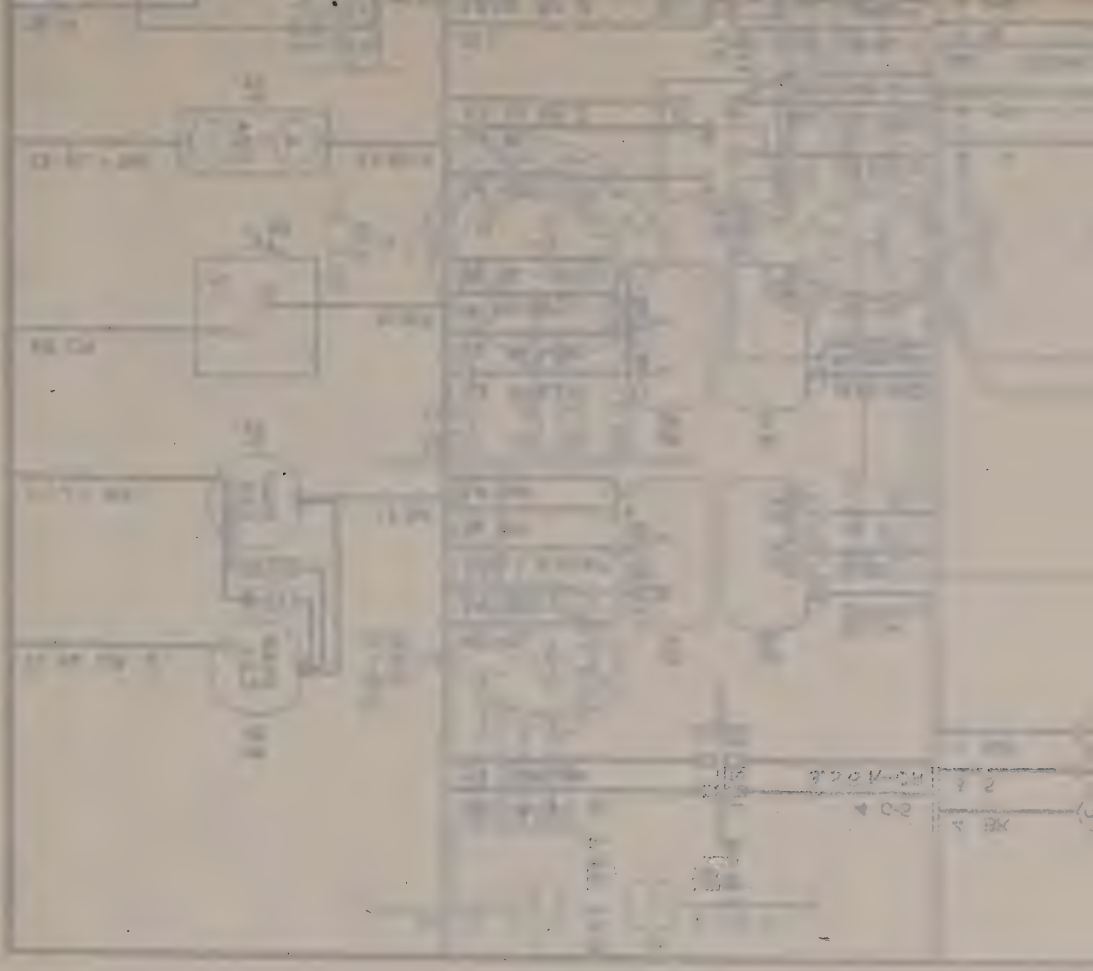
Ref.	Description	Used in Switch Position
R38 A ✱ B	Res. 100 ohm, ±5%, ½ W	S1 1 to 9
R39 A ✱ B	Res. 8,300 ohm, ±5%, ½ W	S1 A only
R40 A ✱ B	Res. 10,000 ohm, ±5%, ½ W	S1 B only
R41 A ✱ B	Res. 10,000 ohm, ±5%, ½ W	S1 8 and 9
R42 A ✱ B	Res. 13,000 ohm, ±5%, ½ W	S1 7 to 9
R43 A ✱ B	Res. 16,000 ohm, ±5%, ½ W	
R44 A ✱ B	Res. 20,000 ohm, ±5%, ½ W	
R45 A ✱ B	Res. 27,000 ohm, ±5%, ½ W	
R46 A ✱ B	Res. 33,000 ohm, ±5%, ½ W	
R47 A ✱ B	Res. 43,000 ohm, ±5%, ½ W	
R48 A ✱ B	Res. 51,000 ohm, ±5%, ½ W	
R49 A ✱ B	Res. 750 ohm, ±5%, ½ W	
R50 A ✱ B	Res. 20,000 ohm, ±1%, ½ W	
R51	Res. 82,000 ohm, ±10%, ½ W	
R52	Res. 82,000 ohm, ±10%, ½ W	

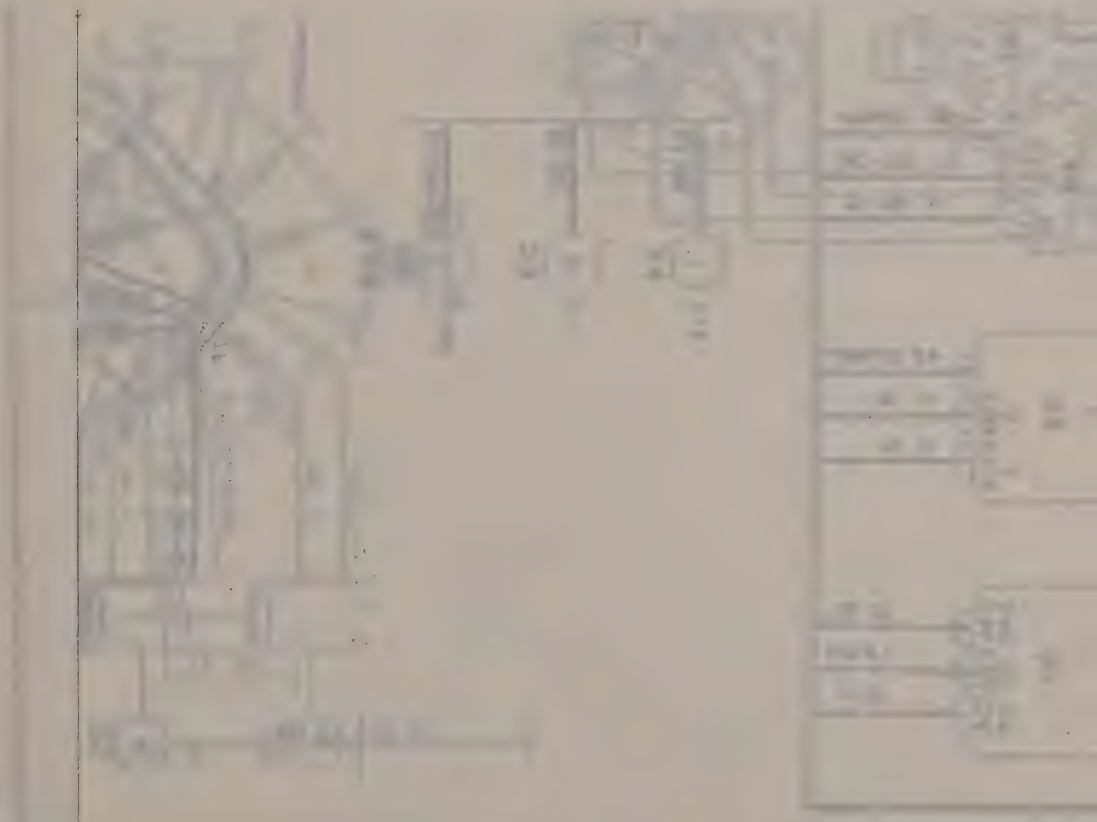
Ref.	Description	Used in Switch Position
•C1 A ✱ B	Cap. .015 mf, ±10%, 600 VDCW	S3 1, 2, 3, 5, 10
•C2 A ✱ B	Cap. .03 mf, ±10%, 600 VDCW	S3 2, 6, 10
•C3 A ✱ B	Cap. .045 mf, ±10%, 600 VDCW	S3 2, 7, 11
•C4 A ✱ B	Cap. .08 mf, ±10%, 600 VDCW	S3 4 to 7
•C5 A ✱ B	Cap. .12 mf, ±10%, 600 VDCW	S3 8 to 11
•C6 A ✱ B	Cap. .2 mf, ±5%, 600 VDCW	S1 1 to 10
•C7 A ✱ B	Cap. .15 mf, ±5%, 600 VDCW	S1 1, 2, 3, 5, 10
•C8 A ✱ B	Cap. .15 mf, ±5%, 600 VDCW	S1 1, 2, 3, 5, 10
•C9 A ✱ B	Cap. .3 mf, ±5%, 600 VDCW	S1 1, 3, 5, 10
•C10 A ✱ B	Cap. .2 mf, ±5%, 600 VDCW	S1 1, 2, 4, 5, 10
•C11 A ✱ B	Cap. .3 mf, ±5%, 600 VDCW	S1 1, 2, 5, 10
•C12 A ✱ B	Cap. .2 mf, ±5%, 600 VDCW	S1 7 to 10
C13 A ✱ B	Cap. .5 mf, ±5%, 600 VDCW	S1 5 and 10
C14 A ✱ B	Cap. .2 mf, ±5%, 600 VDCW	
C15 A ✱ B	Cap. .2 mf, ±5%, 600 VDCW	
C16 A ✱ B	Cap. .15 mf, ±5%, 600 VDCW	
C17 A ✱ B	Cap. .04 mf, ±5%, 600 VDCW	
C18 A ✱ B	Cap. .03 mf, ±5%, 600 VDCW	
C19 A ✱ B	Cap. .2 mf, ±5%, 600 VDCW	
C20 A ✱ B	Cap. .3 mf, ±5%, 600 VDCW	

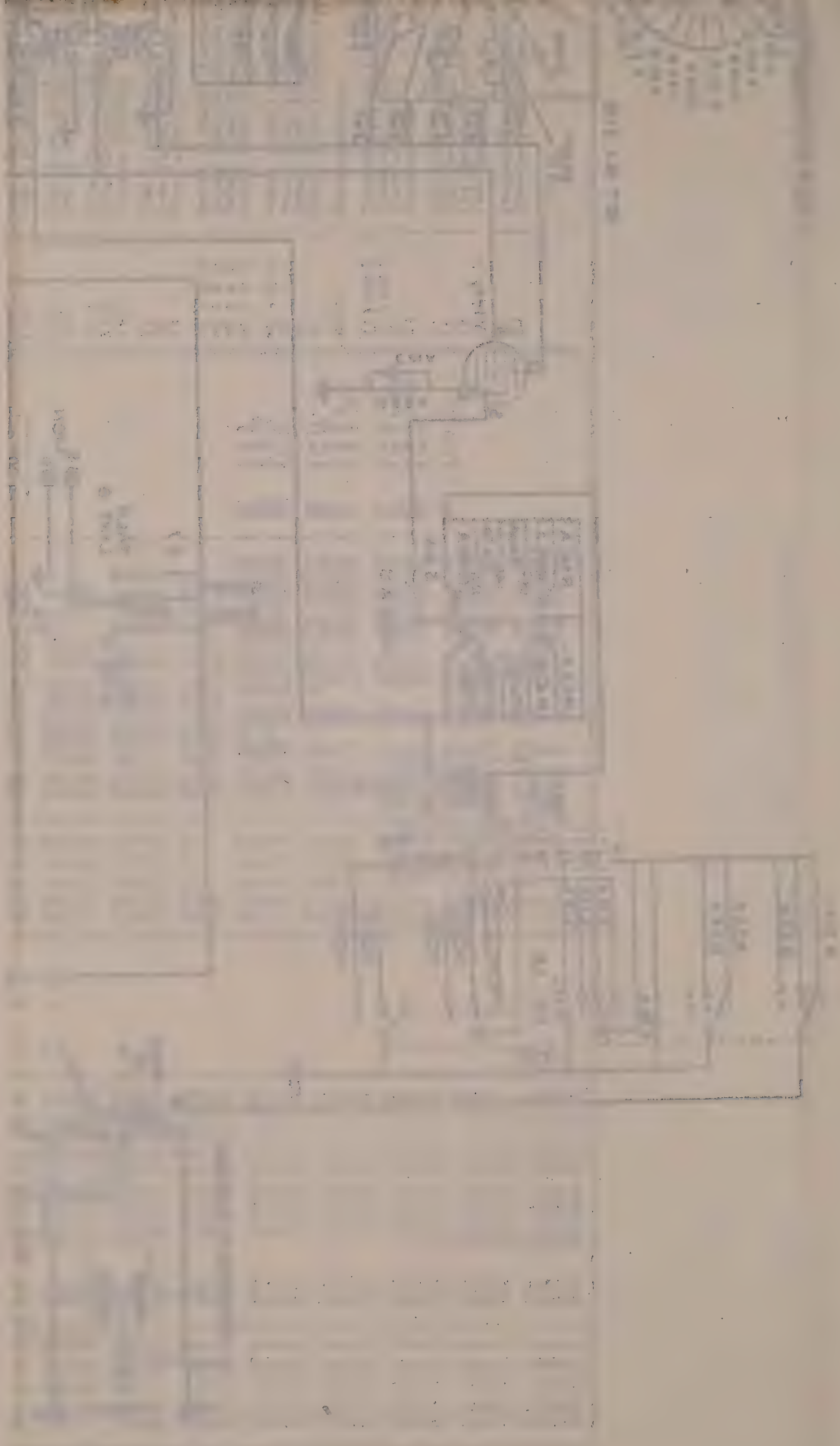
Ref.	Description	Used in Switch Position
C21 A ✱ B	Cap. 2 mf, ±20%–10%, 600 VDCW	
C22 A ✱ B	Cap. 2 mf, ±20%–10%, 600 VDCW	
C23	Cap. 1 mf, ±20%–10%, 1,000 VDCW	
C24	Cap. .1 mf, ±20%–10%, 1,000 VDCW	
C25	Cap. 25 mf, ±150%–10%, 300 VDCW	
C26	Cap. 25 mf, ±150%–10%, 300 VDCW	
F1	Fuse, ½ amp., 250 volt	FT-46
F2	Fuse, 3 amp., 250 volt	FT-27
F3	Fuse, ¼ amp., 250 volt	
S1 A ✱ B	Switch, 12 position, 3 section	
S2 A ✱ B	Switch, 1 pole, 12 position, 2 section	
S4 A ✱ B	Switch, 1 pole, 11 position, 2 section	
S5 A ✱ B	Switch, 5 pole, 3 position, 2 section	
S6	Switch, 4 position	
S7	Switch, 3 pole, 2 position, 2 section	
S8	Switch, 1 pole, 3 position, 1 section	
RECT	Rectifier, selenium	
T1 A and B	Transformer, Audio Input	
T2 A and B	Transformer, Audio Output	
T3	Transformer, Power	
T4	Interstage Coil	
L1	Coil (Power Supply Filter)	
L2	Coil (Power Supply Filter)	
L3	Coil (Simplex Filter)	
L4 A ✱ B	Coil (Equalizer)	
M1	Protector Block (Porcelain)	
M2	Protector Block (Carbon)	

Figure 22. Telephone Repeater TP-14, schematic diagram.









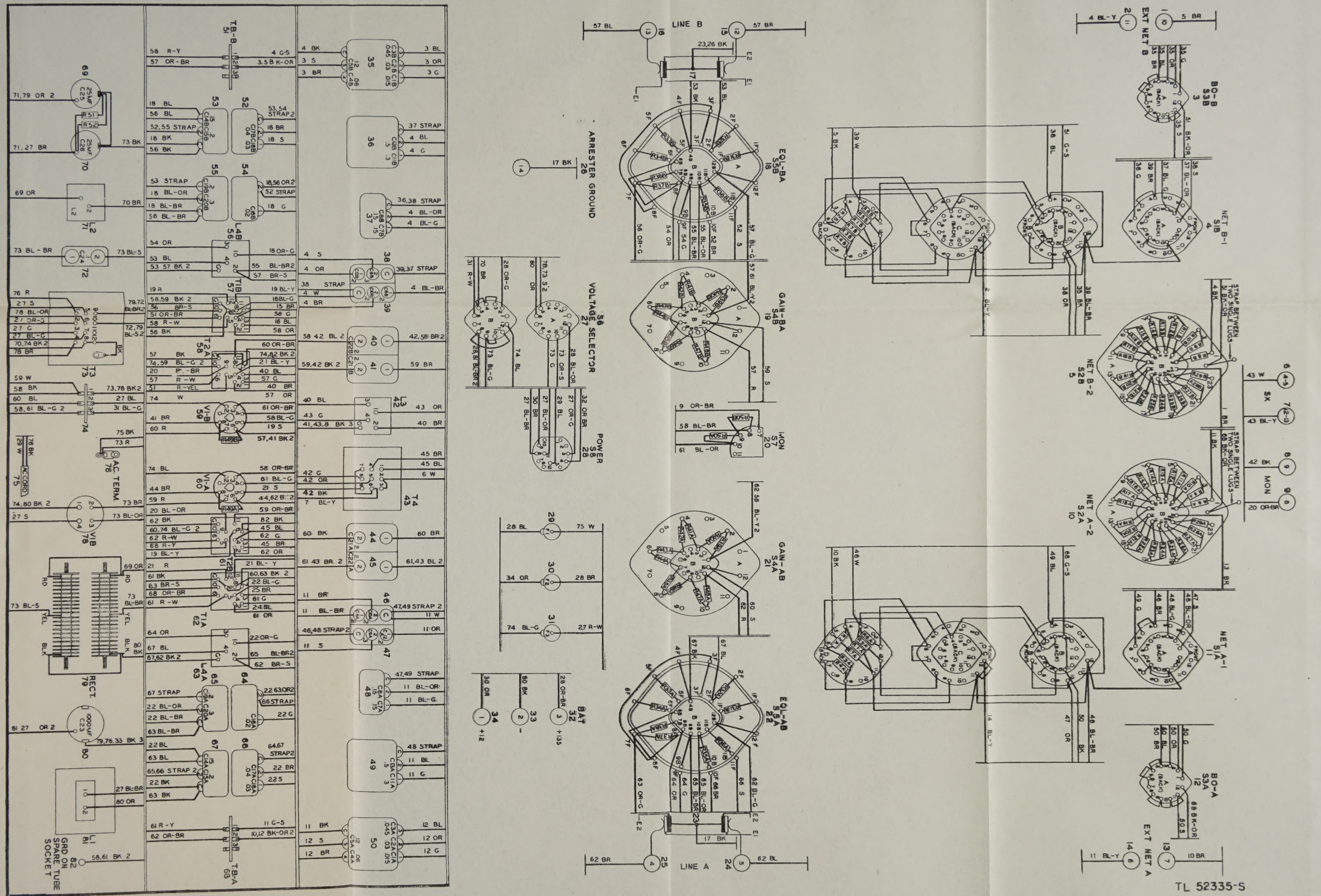
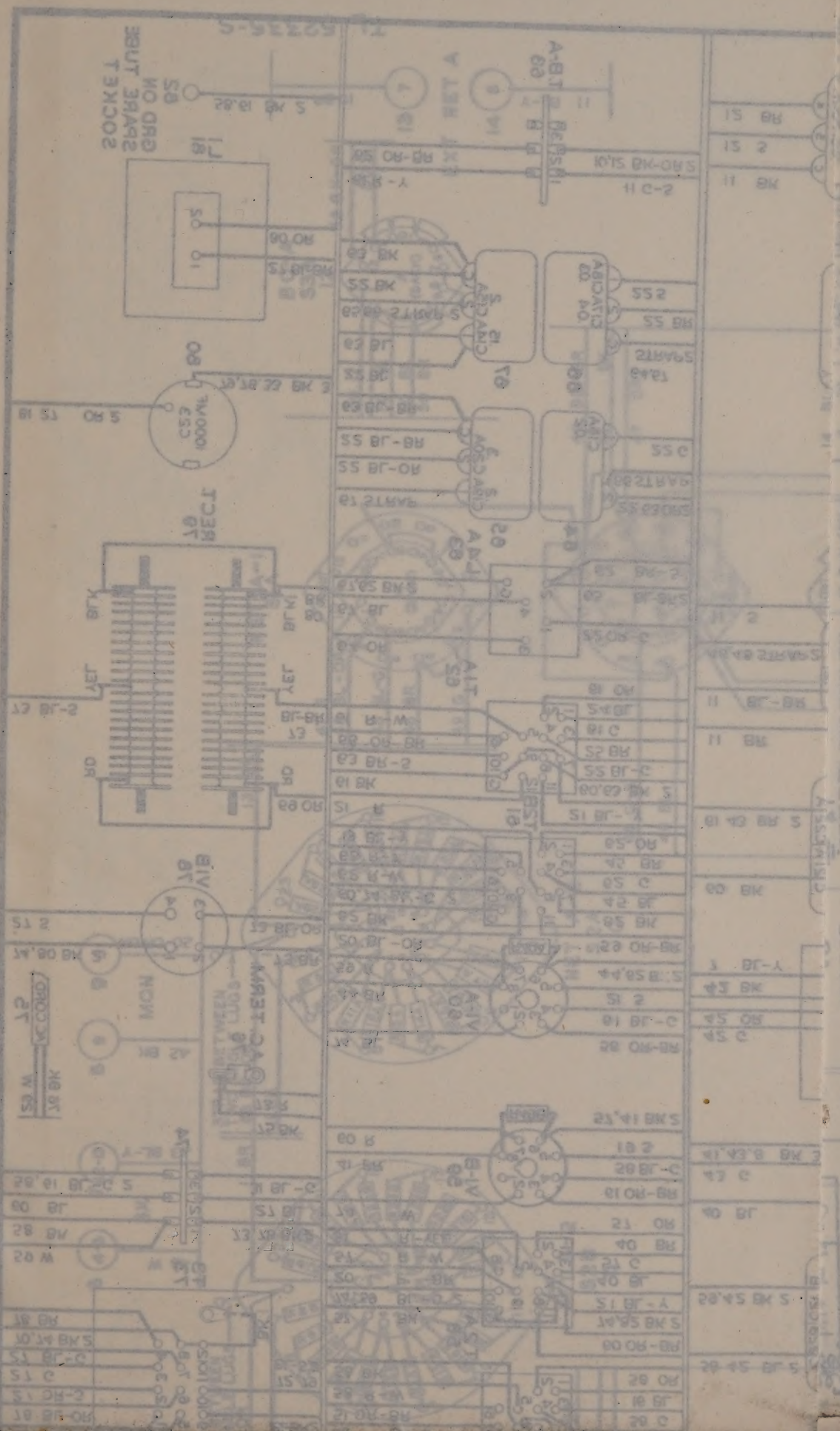



Figure 23. Telephone Repeater TP-14, wiring diagram.